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Tech Notes

DECEMBER 1987

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Center for the Utilization of Federal Technology

U.S. DEPARTMENT OF COMMERCE
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National Technical Information Service
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Tech Notes

Highlighting Selected U.S. Government Technology & Resources

DECEMBER 1987

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Published monthly by the National Technical Information Service (NTIS), Tech Notes bring togeather individual one to two page fact sheets prepared by Federal agencies, their laboratories, or contractors. These fact sheets highlight current Federal technology determined to have commercial or practical application. Topics cover new processes, materials, techniques, software, instrumentation, and resources.

Some of the current sources are the Department of the Navy, Department of the Army, NASA, Department of Energy , Environmental Protection Agency, Department of the Interior, and the Department of Agriculture.

Special assistance is provided by the Federal Laboratory Consortium.

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Every Tech Notes fact sheet lists a source for additional information. The source of this information may be a special support package from the originating agency, a personal contact, a licensing opportunity, or a backup report available from NTIS.

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Sources of Further Backup Information

Below are two representative examples of how each Tech Note fact sheet provides you with a source of further information. In most cases, this information is provided directly by the agency or its laboratory. However, there are cases where NTIS is the source for backup documentation. In these cases, use the order form at the end.

Examples:

significant distance from the endwalls. Therefore, a radial variation in efficiency should be used when designing small stators.
Project Officer Jeffrey E. Haas
(216) 433-4000.

FOR ADDITIONAL INFORMATION

You can learn more about this technology by ordering the NTIS report(s):
Cold-Air Performance of Compressor Drive Turbine
Order number: AD-A101066/NAA
Price code: A02
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Springfield, VA 22161
(703) 487-4650

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- Agency contact who can supplement the information contained in the backup report.
- NTIS Order Number*
- NTIS Price Code*

* See the order form and price code table at the end of the issue.

Suggested applications include other kinds of refrigerators, heat engines, thermal instrumentation, and heat switches.
This work was done by Emanuel Tward of Caltech for NASA's Jet Propulsion Laboratory.
NPO-15479/TN

FOR ADDITIONAL INFORMATION

Contact: Director, Technology Transfer Division, P.O. Box 8587, BWI Airport, MD 21240: (301) 621-0100 Ext.241.
REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE

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Agriculture & Food

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United States Department of Agriculture

Research Technology
Agricultural Research Service

Fruits and Vegetables Kept Fresh With Vitamin C Compounds

Vitamin C derivatives and other compounds prevent browning of cut apples in laboratory tests up to 48 hours and may be alternatives to sulfites for keeping salad-bar-style fruits and vegetables fresh, Agricultural Research Service scientists report.

"We think further studies will show that these compounds prevent browning for at least several days under commercial conditions," says chemist Kevin B. Hicks, leader of a research team at the Eastern Regional Research Center in Philadelphia, PA. "There is industry interest in working with us to test the new uses of these compounds."

Dipping apple slices in either of two classes of compounds closely related to vitamin C—ascorbic acid-2-phosphates and ascorbic acid-6-fatty acid esters—was most effective and prevented browning for up to 48 hours, according to preliminary results of research done in cooperation with scientists at Kansas State University.

The compounds worked on Winesap and Red Delicious apples, Granny Smith apple juice, and potatoes. Further studies may be done with cauliflower, mushrooms, lettuce, and other vegetables and fruits.

"We expect that these compounds will be safe and not affect taste," Hicks says, "but some will require Food and Drug Administration approval before use on food."

Fresh fruits and vegetables begin to turn brown once they are cut, sliced, or peeled. "Exposure to air helps an enzyme, polyphenol oxidase, react with polyphenols, natural chemicals inside these foods," says Gerald M. Sapers, a food technologist who developed the procedures to evaluate these compounds.

Sulfites were the most effective compounds for slowing down this reaction, Sapers says, but the FDA banned them last July for use on raw fruits and vegetables. "Ordinary vitamin C can be used but is effective for only a short time," he says. "The compounds we studied are far more effective than that."

The vitamin C (ascorbic acid) derivatives also controlled browning when mixed with cinnamic acid, beta-cyclodextrin, or a commercial inorganic phosphate compound.

Some of the compounds studied are already used in Japan for various foods, and one of them, ascorbyl palmitate, is used in the United States to preserve fats and oils. ARS is applying for a patent on their use as antibrowning agents.

Kevin B. Hicks and Gerald M. Sapers are in USDA-ARS Plant Science Research, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118.

United States Department of Agriculture

Research Technology
Agricultural Research Service

Drought Tolerance Transferred Between Plants Using a New Microinjection Genetic Engineering Technique

This new genetic engineering system opens vast opportunities to build new crops rapidly to withstand environmental stresses. Using a hair-thin glass needle, an ARS scientist microinjected 30 to 50 genes--making up a chromosome--from a wild, dry-weather petunia into single cells of a commercial petunia variety. Petunias grown from the cells proved more drought tolerant in greenhouse tests. This technique should bridge the gap between cell fusion and single gene transfer.

Technical Information:

Chromosomes were isolated from a drought tolerant species (Petunia alpicola) and microinjected into protoplasts of the cultivated petunia (Petunia hydrida). The injected cells were then screened for the unia expression of foreign protein on polyacrylamide gels. Several cells a were identified which produced stable differences in protein profile. These cells are currently being regenerated into whole plants. This technique could allow the plant breeder to bridge the gap between wide hybridization and DNA transformation where single genes are transferred. Chromosome mediated transformation will allow the transfer of polygenic characteristics between sexually incompatible species.

FOR FURTHER INFORMATION CONTACT:

Robert J. Griesbach
Florist and Nursery Crops Lab,
Beltsville, MD
(301) 344-3574

United States
Department of
Agriculture

Licensing Opportunity

Research Technology
Agricultural Research Service

Low-Cal Sweeteners

Many sodas and candies are sweetened with high-fructose corn syrup made from glucose derived from cornstarch. This common glucose (D-glucose) is just one of many types of natural sugars called aldose sugars. Many of these could be used to produce rare or unavailable forms of ketose sugars that may be useful as low-calorie sweeteners or ingredients of pharmaceutical and other industrial products.

The problem is that the enzymes used by industry to turn glucose into fructose work only with D-glucose and not other natural aldose sugars.

This patented process solves the problem by using different catalysts that convert all types of aldose sugars into ketose forms.

It involves a chemical reaction between an aldose sugar and boric acid dissolved in water and mixed with an amine catalyst.

The process can also be used to convert so-called left-handed sugars like L-glucose into L-fructose, a sugar some claim is as sweet as natural fructose but has no calories.

One caution, though. Products derived from the rare sugars have not yet been approved by the Food and Drug Administration for commercial use.

For technical information, contact Kevin B. Hicks, USDA-ARS Food Biochemistry Research, Eastern Regional Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118.

Patent No. 4,273,922, "Ketose Sugars From Aldose Sugars."

For Additional Information:

A copy of this invention's patent is available from the U.S. Commisioner of Patents, Washinton, DC 20231 for $1.50.

Inquiries concerning rights for commercial use of this invention should be addressed to

Office of Federal Patent Licensing
Center for the Utilization of Federal Technology
Room 13R, NTIS
Springfield, VA 22161
(703) 487-4738

Refer to Patent 4,273,922/TN

United States Department of Agriculture

Research Technology
Agricultural Research Service

Test Quickly Distinguishes the Food Poison Bacteria, Yersinia Enterocolitica

The bacterium, Yersinia enterocolitica can cause disease in humans, and is often found in the food supply. However, not all Y. enterocolitica in foods are potentially disease-causing, since only those containing a specific piece of genetic material on a plasmid (a small circular segment of DNA that is independent of the rest of the cell's genetic material) are disease-producers. A better understanding of this plasmid is needed to establish how the bacterium causes disease, and to allow the development of efficient methods for identifying disease-causing Y. enterocolitica in foods. To that end, a more efficient method for isolating the plasmid was developed. This improved technique should significantly enhance future research into how Y. enterocolitica cause disease, and how the presence of disease-causing Y. enterocolitica can be detected in foods.

Technical Information:

The method utilizes the molecular characteristics of covalently closed circular (supercoiled) plasmid DNA that is released from cells under conditions that denature chromosomal DNA with the use of alkaline sodium dodecyl sulfate. Upon neutralization, chromosomal DNA renatures to form an insoluble clot, whereas plasmid DNA remains in the supernatant. Under these conditions, the concentration of chromosomal DNA is markedly reduced. Plasmid DNA is recovered from the supernatant by isopropanol precipitation and is resuspended in buffer followed by extraction with phenol-chloroform solution to prevent nicking of covalently closed circular plasmid DNA. Plasmid DNA in the aqueous phase is precipitated with ethanol and is further purified by CsC1 - ethidium bromide buoyant density-gradient centrifugation. Application of this technique yields plasmid DNA compatible with restriction enzymes and thus suitable for molecular biological procedures.

FOR FURTHER INFORMATION CONTACT:

Dr. Saumya Bhaduri
USDA-ARS-ERRC
600 E. Mermaid Lane Philadelphia, PA 19118
(215) 233-6521

Computers

1152 Design 4D—A Microprocessor Driven Architectural Design System

1153 New Standards for Connecting Storage Devices to Computers

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US Army Corps of Engineers

Fact Sheet

Construction Engineering Research Laboratory

Design 4D—A Microprocessor Driven Architectural Design System

Computer systems for assisting in the architectural design process have been in development for several years. However, most of this development has been more concerned with the technical aspects of making a computer system work rather than addressing the issue of the "fit" of the computer-based system to the ways in which architects go about the design process. The ultimate success of a computer-based design tool might rest in the way that it is, or is not, congruent with the user's design process. To the extent that it demands the user adopt a new process, it is possible that both the quality and speed of the solution would be adversely affected. DESIGN-4D is a microbased computer system that has been developed to assist the architect in the concept design process, making available several alternatives of design methodology.

The Technology

A full three-dimensional drawing capability has been developed which is very easy to learn and use. The external interfaces to the complicated underlying software have been developed to be of no threat to the user. DESIGN-4D is a very sophisticated software package that runs on the AT* class microprocessor using state-of-the-art hardware and software technology to achieve response speeds only possible before on larger and more costly machines.

DESIGN-4D has the following important capabilities and features:

1. Full 3D drawing capabilities in any direction in three-dimensional space.

2. Full 2D drawing capabilities with automatic extrusion to 3D.

3. A geometric engine for creating and manipulating spatial volumes.

4. A geometry database fully integrated with the geometric engine. This database removes all previously existing limits to the amount of data that can be stored and manipulated.

5. An attribute database that permits data storage and retrieval for all disciplines in the building design process. This attribute database interacts automatically with the geometric engine and geometry database.

6. Multiple views of the design with instantaneous updating in all views.

7. Dynamic graphical interaction with the database manager.

8. Many alternatives for design methodology.

9. Interface to the AutoCAD* drafting program through DXF data exchange.

10. Software expandable to perform "intelligent" design analysis during the design process.

The Benefits/Savings

With DESIGN-4D the architect will be able to quickly develop many design ideas with reduced effort. Utilizing the full three-dimensional space manipulation capabilities, the architect will be able to create massing models and place openings on their elevations, and will be presented with design analyses and criteria checking during the design session. Benefits and savings are predicted from higher quality design and shorter design times.

Status

A prototype of DESIGN-4D has been completed and will undergo testing in July 87. This prototype contains a complete 2D and 3D geometric engine, geometry databases, space manipulation routines, and viewing capabilities. The DXF interface to AutoCAD is also included.

FOR FURTHER INFORMATION CONTACT:

Mr. Mike Golish, 217-373-7270 or Mr. Kenneth H. Crawford, 217-373-6717. Army Corps of Engineers, Construction Engineering Research Laboratory, P.O. Box 4005, Champaign, IL 61820 Both can be reached toll-free on 800-USA-CERL (outside Illinois), or 800-252-7122 (within Illinois).

NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

New Standards for Connecting Storage Devices to Computers

The Secretary of Commerce has approved two new Federal Information Processing Standards (FIPS) which should reduce the government's costs of mass storage equipment such as magnetic disk and tape devices. Adopting voluntary industry standards that were developed with NBS assistance, the new standards define the functional, electrical, and mechanical specifications for an intelligent peripheral interface and a small computer system interface. These standard interfaces should improve the ability to interchange storage equipment and broaden sources of supply, thus reducing costs for initial acquisitions as well as replacement. Both standards become effective Dec. 16, 1987.

For Additional Information:

For information on ordering, contact the National Technical Information Service, Springfield, Va. 22161. Refer to FIPS-PUB 130, Intelligent Peripheral Interface (1P1), or FIPS-PUB 131, Small Computer System Interface (SCSI). FIPS 130 adopts ANSI X3.129-1986; X3.147-1986; X3.132-1986; and X3.130-1986. FIPS.131 adopts ANSI X3.131-1986.

NASA Tech Brief
National Aeronautics and Space Administration

Acquisition-Management Program

Data are maintained on contracts, grants, and purchases.

The NASA Acquisition Management Subsystem (AMS) program is an integrated NASA-wide standard automated-procurement-system program that was developed in 1985. AMS is designed to provide each NASA installation with a procurement data-base concept with on-line terminals for managing, tracking, reporting, and controlling contractual actions and associated procurement data.

The subsystem provides control, status, and reporting for the following areas of procurement: bidders source system; purchase-request tracking; award information for purchase orders, contracts, and grants; contract and grant administration; and contract and grant closeout. The purpose of this standardization is to decrease the costs of procurement and of the operation of automatic data processing; increase procurement productivity; furnish accurate, on-line management information; and improve customer support.

AMS can provide detailed procurement information from the start of the procurement through contract award, contract administration, and subsequent contract closeout: it is a daily working tool for the procurement and technical team in the day-to-day accomplishment of tasks. Summary-level data for procurement managers are also available. To satisfy NASA Field Center procurement organizations and NASA Headquarters reporting requirements, a historical data base of all procurement actions is maintained. In addition to being the acquisitions management subsystem for each NASA installation, the AMS also serves as a feeder system for the NASA Headquarters Financial and Contractual System (FACS) and the Federal Procurement Data System (FPDS) for the Office of Management and Budget.

Other procurement organizations will probably need to modify the AMS code to suit their procurement nomenclature and procedures. AMS installation and modification requires a thorough understanding of the ADABAS DBMS and the NATURAL programming languages.

AMS is written in the ADABAS NATURAL language and has been implemented on an IBM 4381 Group 2 machine with 4 megabytes of memory and operating under OS MVS/SP3. AMS is designed to use an IBM 3705 TCU to support IBM 3270 terminals. The subsystem requires the following IBM software: ACF-VTAM, JES2, and CICS. It also requires the following Software AG software: ADABAS, NATURAL SECURITY, and PREDICT.

This program was written by Don E. Avery, A. Vernon Vann, Richard H. Jones, and William E. Rew of **Langley Research Center**. *LAR-13588 /TN*

FOR ADDITIONAL INFORMATION *CONTACT:*

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Electrotechnology

1155 Integrated Circuits with 1-Micron Features

1156 Selective Etching of Compound Semiconductors Possible

1157 Transient Protection of Electronic Circuits — Report reviews protection from different forms of electromagnetic pulses

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1162 Controller for a High-Power, Bruchless dc Motor — Driving and braking torques are controllable.

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1164 More Abstracts on Effects of Radiation on Electronic Devices — A previously published bibliography is augmented. (Licensing Opportunity)

1165 Ensuring Fully Soldered Through Holes — A vacuum draws solder into holes, even in thick circuit boards.

Integrated Circuits with 1-Micron Features

A major technology development and transfer program between Sandia National Laboratories and AT&T Bell Laboratories has achieved significant progress in just one year of operation.

The program's current schedule calls for engineering prototypes by mid-1988 of fully radiation-hardened complementary metal oxide semiconductor (CMOS) integrated circuits with 1-micron features. The smallest features on today's most widely used, thoroughly hard CMOS circuits are 2 microns.

Sandia is home for the Center for Radiation-Hardened Microelectronics (CRM), which is working with Bell Labs on the project.

This joint effort is one of a number of technology transfer and exchange programs that are being conducted by the CRM with private industry. It is being carried out under terms of the contract that covers Sandia's operation. Sandia is operated for the U.S. Department of Energy (DOE) by AT&T Technologies, Inc. One portion of the contract calls for Bell Labs to perform research and development for Sandia that DOE, AT&T, and Sandia all deem to be important and appropriate.

Each tiny integrated circuit (IC) that is fabricated with the new Bell Labs/CRM technology could contain more than a million transistors. The chips will function as microprocessors, computer memories, and application-specific ICs that will find their way into future weapons, space, and satellite systems.

Immune to single event upset

To be useful in these environments they will be single event upset (SEU)-immune and able to operate successfully after a total dose of at least a million rads of ionizing radiation. (SEU is the temporary scrambling of one or more memory bits due to a high-energy particle or cosmic ray hitting an IC memory cell. A whole body dose of about 1,000 rads of ionizing radiation is typically fatal to humans.)

CRM engineers believe that with some design tradeoffs the new ICs can be made to work after a 10-million-rad total dose, as is the case with 3-micron-feature chips that Sandia designed and built at the CRM in 1985.

Current plans are to build the 1-micron rad-hard chips at the new Radiation-Hardened Integrated Circuit (RHIC) facility that is scheduled to begin operation at the CRM late this year. It may be necessary to first produce the devices at the Bell Labs facility in Allentown, Pa.

Actual R&D is being carried out primarily at Bell Labs, with funding from both organizations. Since March 1986, Bell Labs has fabricated Sandia's hardened two-level metal 16K static random access memory (RAM) using its 1-micron process sequence. Minimum feature sizes, however, are 2 microns.

In addition, Sandia and Bell Labs personnel jointly designed a test chip using the developing 1-micron technology. Fabrication is underway at Bell Labs.

The test chip contains eight RAM memory cell layouts that use different design rules and techniques. Experiments will permit designers to identify the best of the eight in terms of use of space, reliability, and SEU tolerance. Following the memory cell choice, a 64K static RAM will be constructed using that cell design.

The project's schedule calls for definition of final design rules and process sequences by mid-1987, and first engineering prototypes of 1-micron ICs by mid-1988.

Significant technology achievements originated at both Sandia and Bell Labs have helped to move the project forward.

One major Sandia contribution is a new IC processing technique that permits rad-hard chips to have two levels of metal wires (called interconnects).

"Development of a hardened two-level metal IC was slowed because the additional processing steps required to add a second layer of conducting lines compromised hardness," says Bob Gregory, Sandia's Director of Microelectronics. "The new technique can be done without degrading hardness."

Controls via formation

Keys include a new first-level metal material, cooperative use of film deposition and etching to create a flat insulation layer that separates metal layers, and an ability to carefully control the formation of vias—holes in an IC's insulation layers that permit connection of metal lines located on different levels.

Primary Bell Labs contributions, besides basic VLSI processing, include novel approaches that yield thinner and flatter insulative glass layers on ICs and special resistors that operate consistently over a wide temperature range, while providing a shield against cosmic ray-induced SEU.

These contributions, refined at Bell Labs for the specific task at hand, draw from related CRM research and development.

The CRM was established at Sandia in 1980 to develop technologies and design capabilities for production of large-scale and very large-scale ICs capable of operating in high-radiation environments and to transfer those capabilities to private industry for commercial production.

RHIC is the CRM's newest major facility. It will have a unique 12,500-ft^2 Class 1 wafer fabrication clean room, meaning that less than 1 particle of 0.12-micron size or larger will be present per average cubic foot of air space.

Sharing technology with industry

The work with Bell Labs is one of the most recent highlights of the CRM's commitment to share technology with private industry. A somewhat different example is that of aid to Martin-Marietta in establishing itself in the manufacture of the CRM's 2-micron rad-hard CMOS

technology. As a means of reaching this goal, Martin-Marietta has built a major semiconductor fabrication facility in Orlando, Fla.

Other examples include Sandia's 1976 transfer of a 10-micron feature technology—state-of-the-art then—to National Semiconductor, 1983 transfer of a 16K static RAM to Harris Corporation, and last year's agreement with Intel to begin development of a rad-hard version of Intel's 80C51 microcontroller.

Another type of CRM technology transfer activity has involved the sharing of technical concepts and procedures with industry. Many of these have ramifications for the silicon semiconductor industry as a whole.

CRM research has advanced the basic understanding of plasma etching, a manufacturing step that selectively removes the thin films deposited on wafers in such a way that specific features such as lines remain.

"We showed that many related process parameters control plasma etching of aluminum," says Ron Light, supervisor of the IC Lithography & Pattern Technology Division. "The relationships are the main reason why it had been so difficult for scientists to understand all the mechanisms governing aluminum etching."

FOR ADDITIONAL INFORMATION

Public Information Division,
Code 3161,
Dept. of Energy,
Sandia National Laboratories,
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Refer to announcement 22, No. 5

Selective Etching of Compound Semiconductors Possible

A new technique that allows selective dry chemical etching of compound semiconductors, such as gallium arsenide phosphide, has been developed at Sandia National Laboratories. It exploits electronic differences as a means of discriminating between chemically similar semiconductor materials.

This discovery could be a boon to future solid state device design and fabrication. In particular, it stands to benefit compound semiconductors, which are being used increasingly as research and development advances occur.

Conventional dry chemical etching, developed primarily for use during fabrication of silicon-based semiconductor devices, achieves selectivity by discriminating between chemically dissimilar materials, such as silicon and silicon dioxide.

Such techniques, however, are of limited use with compound semiconductor technology, in which it is frequently necessary to etch one material, while leaving an adjacent chemically similar material intact.

In many cases, compound semiconductors are more readily adaptable than conventional silicon for use in high-speed, high-temperature, and high-radiation environments. They also are used in a class of Sandia-developed semiconductor materials called strained layer superlattices.

Compound semiconductor devices are currently used in optical telecommunication systems, laser printers, robotic vision components, laser compact disk players, optical radars, and crucial parts of Earth-station satellite broadcast receivers.

Carol Ashby of Sandia's Laser & Atomic Physics Division adjusts the mounting fixture that holds samples of semiconductor materials ready for etching by a laser beam. Ashby has used tunable dye lasers to achieve the right wavelengths for etching specific materials.

The new dry photochemical etching technique—successfully demonstrated in a series of laboratory experiments that involved etching gallium arsenide phosphide and gallium arsenide materials—received two U.S. Patents (4,648,936 and 4,648,938). They were issued to the U.S. Department of Energy (DOE) in the names of Carol Ashby and James Dishman, both of Sandia's Laser & Atomic Physics Division.

Bombards semiconductor with photons

The technique operates basically by using a light source, such as a laser, to bombard the semiconductor with photons. The photons carry a precisely determined amount of energy, sufficient to create free electrons and holes in the material that is to be etched, but not in adjacent or underlying material with different electronic properties.

The work earned Ashby the DOE's Basic Energy Sciences 1986 award for "significant implication for DOE-related technologies" in materials science research.

One variation of the new technique etches only materials with band gaps of a certain maximum energy level. A semiconductor's band gap—one of its major electronic traits—is the amount of energy required to excite the device's charge carriers (negatively charged electrons and positively charged holes) from a nonconducting state to a state in which they are free to move in an electric field, creating current.

Another variation of the technique can selectively etch any semiconductors whose chemically similar regions are electronically different because of different doping levels. Dopants are impurities—selenium or zinc, for example—that designers add to give semiconductors specific electronic characteristics.

Semiconductor device fabrication typically involves numerous etching operations, usually by chemical means.

As feature sizes of semiconductor devices continue to decrease, the need for highly selective etching processes that remove thin layers of material without disturbing adjacent or underlying layers becomes increasingly important.

Established processes are inadequate

However, established dry etching processes, such as plasma etching, reactive ion etching, or ion-beam-assisted etching, show little, if any selectivity between materials that differ only slightly in composition or doping level.

"A high degree of etching selectivity through chemical effects alone is simply not possible because the chemistry of a typical compound semiconductor material changes very little as the relative proportions of its ingredients are varied from level to level on a device," explains Ashby. "In contrast, certain electronic properties, such as

band gap, change significantly with only minor composition changes."

Ashby's laboratory experiments involved having gallium arsenide phosphide films of slightly different compositions grown onto standard gallium arsenide substrates. She then placed the substrates into a reaction chamber that could be filled with hydrogen chloride gas. One film had an arsenic-to-phosphorus ratio of 1.7:1, giving it a band gap energy of 1.8 eV at 100°C; the other had a ratio of 4:1 and a band gap energy of 1.58 eV.

Then she focused a laser beam on the samples. The beam was precisely tuned to a frequency that gave it an energy of 1.62 eV. It was not intended to burn holes in the films. Rather, it provided photons of sufficient energy to excite non-conducting valence electrons located in the arsenic-rich 1.58-eV bandgap material so that the electrons crossed the band gap to the conduction band. By doing so, the chemical reactivity of the gallium arsenide phosphide increased.

Volatile chemicals evaporate

This permitted a chemical reaction between chlorine in the gas and the gallium, arsenic, and phosphorus in the film producing gallium chloride, arsenic chloride, and phosphorus chloride where the laser had been focused. Etching occurred as these volatile products evaporated from the surface of the 1.58-eV band gap test sample.

No etching occurred on the other test sample, however, because the 1.62-eV photons were not of a high enough energy to start the chemical reaction.

There already is evidence of the commercial potential for this band gap selective etching technique. United Technologies, of East Hartford, Conn., used principles of it to wet-etch gallium arsenide from an aluminum gallium arsenide substrate.

FOR ADDITIONAL INFORMATION

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Refer to announcement 22, No. 5

U.S. Air Force
Technology Note

Transient Protection of Electronic Circuits

Report reviews protection from different forms of electromagnetic pulses

Because many modern semiconductor devices (small signal transistors, integrated circuits) can be damaged by potential differences that exceed about 20 to 40 V, the survivability of modern electronics is limited. Modern electronic technology has tended to produce smaller and faster semiconductor devices, particularly high-speed digital logic, microprocessors, metal-oxide-semiconductor (MOS) memories for computers, and GaAs field effect transistors (FETs) for microwave use. This progress has led to an increased vulnerability of modern circuits to damage by transient overvoltages, because of the inability of small components to conduct large currents.

Electromagnetic pulses from nuclear weapons, lightning, and electrostatic discharge are three examples of such electrical overstress. Such overstress can cause failure, permanent degradation, or temporary malfunction (upset) of electronic devices and systems. This problem and general solutions have been reviewed in a technical report. Nonlinear components and circuits for protection for electrical overstress are discussed in detail, emphasizing spark gaps, metal oxide varistors, and avalanche diodes. However, other components, such as semiconductor diodes, thyristors, resistors, inductors, and optoisolators are also discussed. Applications of these nonlinear components are discussed in the context of signal lines, AC power lines, and DC power supplies. A final chapter discusses specific upset protection circuits.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.
NTIS order number: AD-A178945/2/NAC

NASA Tech Brief
National Aeronautics and Space Administration
Langley Research Center, Hampton, Virginia

Licensing Opportunity

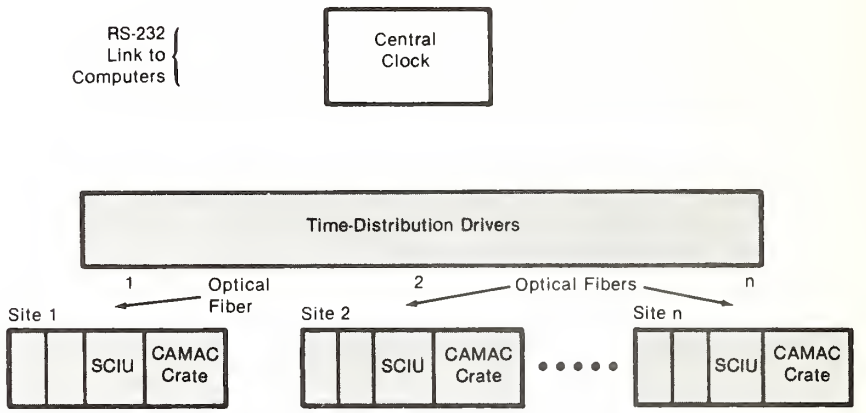
Real-Time Simulation Clock

A fiber-optic network delivers time signals to widely separated simulator sites.

Real-time digital flight simulation at Langley Research Center is used to support a variety of research programs. The majority of this research involves man-in-the-loop simulation requiring the interconnection of digital computers, simulation cockpits, control consoles, graphics subsystems, and related equipment. The real-time simulation subsystem consists of several CYBER® computers and over 20 simulation sites. The system allows for several simultaneous simulation jobs on one CYBER® as well as any combination of sites in each integrated simulation job.

Of a number of alternatives studied for system upgrading, only a network and input/output system conforming to the international Computer Automated Measurement and Control (CAMAC) standards met the requirement for the replacement subsystem. A combination of off-the-shelf and newly designed CAMAC hardware is currently being installed. A CAMAC serial highway provides a distributed input/output system with extremely high data throughput and a direct interface.

In this system, the real-time simulation (RTS) clock provides the timing information for the synchronization of events throughout the RTS system and between the CYBER's®. The centrally located RTS clock generates the timing information and transmits it to the site-clock interface units (SCIU) located at the simulation sites (see figure). The network connecting the central clock to the SCIU's is a fiber-optic system that radiates from the central clock area to the remote sites. It consists of the time-distribution drivers and the fiber-optic cables routed to the sites. The central clock is connected to the simulation computers via RS-232 links.



The **Real-Time Simulation Clock** features independent multiple-job capability.

The central clock consists of a MULTIBUS® -based system including an iSBC® 80/24 processor, an iSBC® 534 communication board, a 5-MHz oscillator board, and a time-interval-generating board. The processor initializes the central clock and responds to status requests from the CYBER's®. The communication board provides the RS-232 linkage to the CYBER's®. The oscillator board contains an oven-controlled 5-MHz crystal oscillator on which all timing information is based. The time-interval generator is a circuit card designed and built in-house to generate all timing information to be distributed to the sites.

The time-distribution drivers consist of CAMAC cards containing fiber-optic transmitters that receive the encoded timing information from the central clock and transmit it to the sites. The SCIU is a single-width CAMAC module that receives and decodes the timing information. It uses this information to generate frame timing for equipment at the site, to synchronize events with other sites, and to send timing information back to the CYBER's® via the CAMAC serial highway.

® MULTIBUS and iSBC are registered trademarks of INTEL.

® CYBER is a registered trademark of CDC.

This work was done by Donald R. Bennington of **Langley Research Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center Refer to LAR-13615./TN

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NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

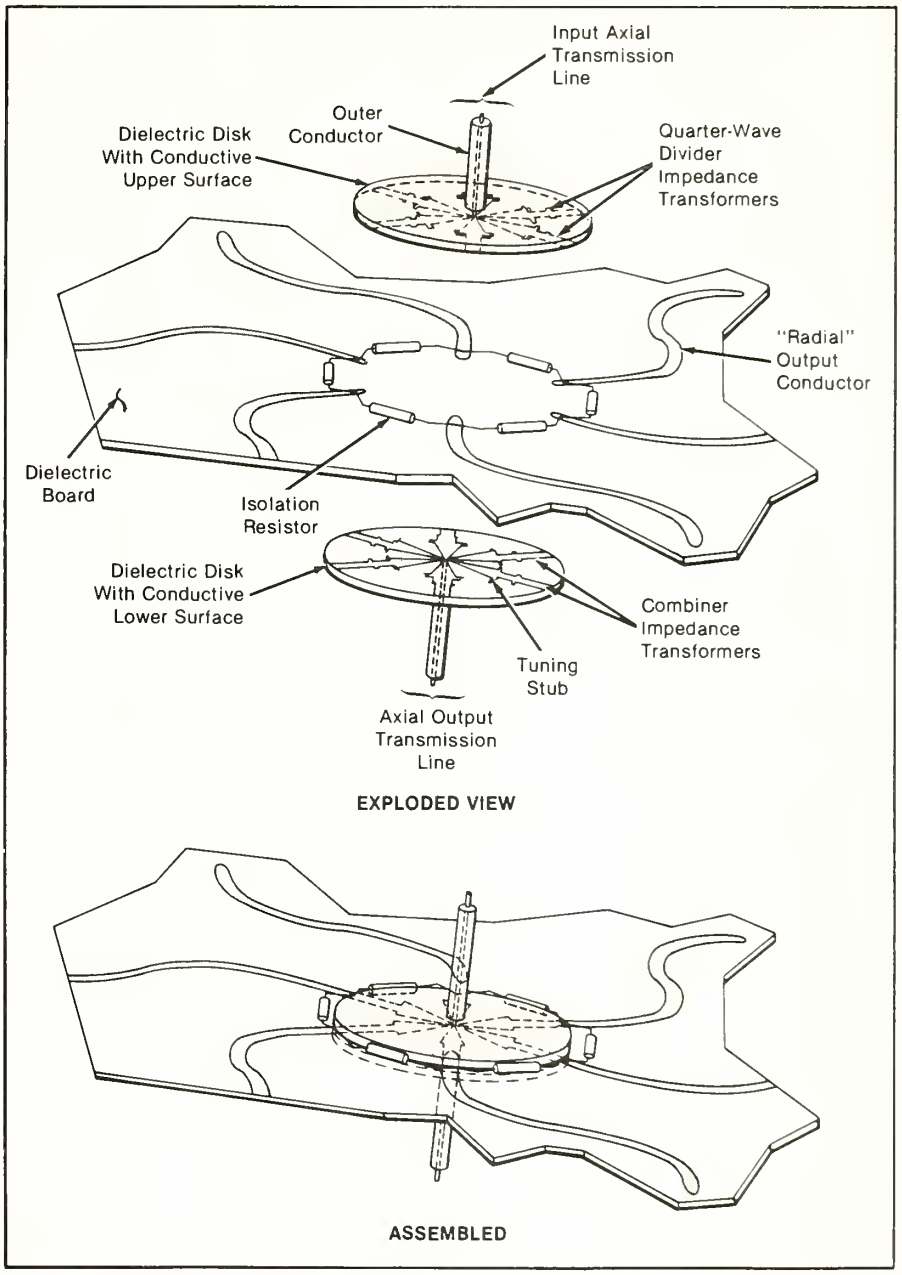
Radial/Axial Microwave Power Divider/Combiner

Parts are made on printed-circuit boards.

A variable coupling device divides or combines microwave power along an axial transmission line and/or a number of radial transmission lines. The device is made partly of electrically insulating boards coated on both sides with conductive copper foil in which circuit patterns are formed by standard printed-circuit techniques.

The device (see figure) includes a dividing-disk structure, a combining-disk structure, and an intermediate dielectric board that holds the generally radially oriented output conductors. The outer conductive surfaces of the dividing and combining disks are connected to the outer conductors of the input and output coaxial transmission lines, respectively. The conductive inner surface of the dividing disk is partly etched away, leaving a set of quarter-wave, power-dividing impedance transformers — one for each radial output conductor — to match the impedances of the output conductors to that of the input transmission line. A similar set of power-combining impedance transformers is etched onto the inner surface of the combining disk, except that the match in this case is to the output axial transmission line.

The radial output conductors are formed on the side of the dielectric board facing the dividing disk. The outer ends of the divider impedance transformers make electrical contact with stubs at the inner ends of the radial output conductors. Isolation resistors are connected between adjacent stubs to tie together the phases at all the radial outputs. In a typical system with 50-Ω input and output coaxial lines, these resistors would be 100 to 150 Ω each. The equal division of power and the equality of phase at equal radial distance along each radial output line are highly desirable in such applications as feeding multiple antenna elements.



Impedance-Matching and Power-Dividing transmission-line strips are formed on insulating disks and on a board by printed-circuit techniques. Power from the input transmission line is sent equally through the radial output conductors to radial output transmission lines and/or is coupled in varying degrees to an axial output transmission line.

Conductive patches are placed on the other side of the board (hidden in the figure), directly opposite the inner ends of the output radial conductors. The patches are thus capacitively coupled to the outer ends of the power-dividing impedance transformers, electrically in parallel with the output radial conductors. Phase-equalizing isolation resistors are also connected between these patches. The outer ends of the impedance transformers on the combining disk are connected to the patches.

The amount of axial coupling between the input and output axial transmission lines is determined chiefly by the thickness of the dielectric board. For maximum coupling, the combining and dividing disks are both aligned with each other and with the conductive pattern on the board. Provided that the necessary electrical contacts are maintained, the dividing and combining disks can be rotated slightly out of alignment to detune the device away from maximum coupling. The divider can also be operated as a combiner by reversing the flow of current.

This work was done by Yerriah P. Vaddiparty of Ford Aerospace and Communications Corp. for **NASA's Jet Propulsion Laboratory**. *NPO-16966 /TN*

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NASA Tech Brief
National Aeronautics and Space Administration
Goddard Space Flight Center, Greenbelt, Maryland

Oscillator or Amplifier With Wide Frequency Range

Inductive and capacitive effects are synthesized with feedback circuits.

An oscillator/amplifier is resistively tunable over a wide frequency range. Feedback circuits containing operational amplifiers, resistors, and capacitors synthesize the electrical effects of an inductance and capacitance in parallel between the input terminals. The synthetic inductance and capacitance, and, therefore, the resonant frequency of the input admittance, are adjusted by changing a potentiometer setting.

The oscillator/amplifier circuit is shown in Figure 1. The input signal is introduced in parallel to the noninverting input terminals of operational amplifiers A_1 and A_2 and to the potentionmeter cursor. The voltages produced by the feedback circuits in response to input voltage V_i are indicated at the various circuit nodes.

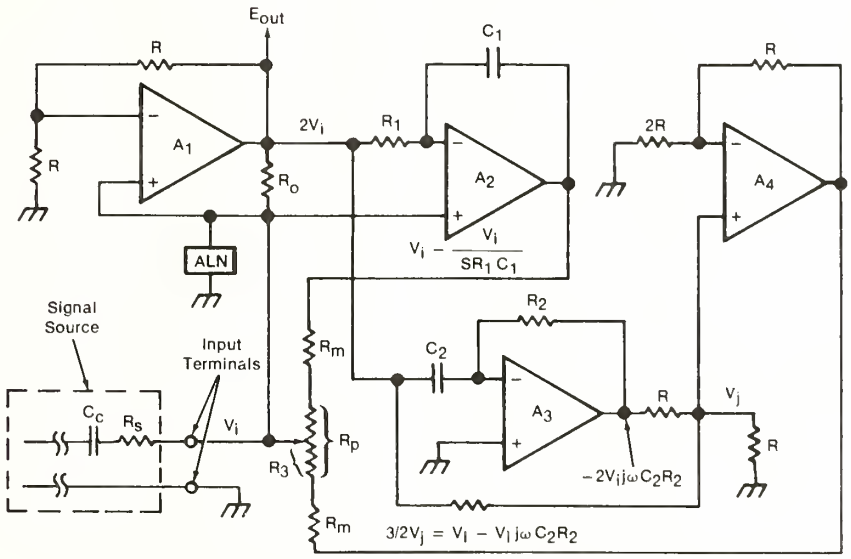
Extracting only those nodal voltages that affect the input current, the equivalent circuits of Figure 2 are constructed. The current in the upper branch of the potentiometer is given by $I_2 = V_i/[j\omega C_1 R_1 (R_m + R_3)]$, which is equivalent to the current that would flow in an inductance $L_{eq} = C_1 R_1 (R_m + R_3)$ connected between the input terminals. The current in the lower branch of the potentiometer is given by $I_3 = V_i j\omega\, C_2 R_2 \times (R_m + R_p - R_3)$, which is equivalent to the current that would flow in a capacitance $C_{eq} = C_2 R_2/(R_m + R_p - R_3)$ connected between the input terminals.

The synthetic parallel combination of inductance and capacitance has a resonant frequency

$$f = \omega/2\pi = (1/2\pi \sqrt{R_1 C_1 R_2 C_2}) \times [(R_p + R_m - R_3)/(R_m + R_3)]^{1/2}$$

Since the extreme potentiometer settings are $R_3 = 0$ and $R_3 = R_p$, the ratio of maximum to minimum resonant frequency is $(R_p + R_m)/R_m$. Thus, the circuit can be tuned over a wide frequency range by adjusting the potentiometer. For example, using the practical values $R_p = 1\ M\Omega$ and $R_m = 1\ k\Omega$, the maximum frequency is 1,001 times the minimum frequency. This represents a much wider tuning range than is available from conventional resistively tuned resonant circuits.

The equivalent negative resistance signifies that power is generated by the circuit at the resonant frequency. If R_o is less than the source resistance R_s, enough power is generated to sustain



NOTES: 1. A_1, A_2, A_3, and A_4 are operational amplifiers
2. ALN = Amplitude-Limiting Network

Figure 1. The **Oscillator/Amplifier Circuit** is built up from feedback circuits containing operational amplifiers, capacitors, fixed resistors, and one variable resistor.

oscillations, in which case the amplitude-limiting network is used. If R_o exceeds R_s, the oscillations are not sustained and the circuit acts as a tuned amplifier.

$$Q = \omega L_{eq}/R_s = 1/\omega\, C_{eq}R_s$$
$$= (1/R_s)[C_1R_1(R_m + R_3)(R_m + R_p - R_3)/C_2R_2]^{1/2}$$

The output is taken from the output terminal of A_1.

This work was done by L. Kleinberg and J. Sutton of **Goddard Space Flight Center**. *No further documentation is available. GSC-12960 /TN*

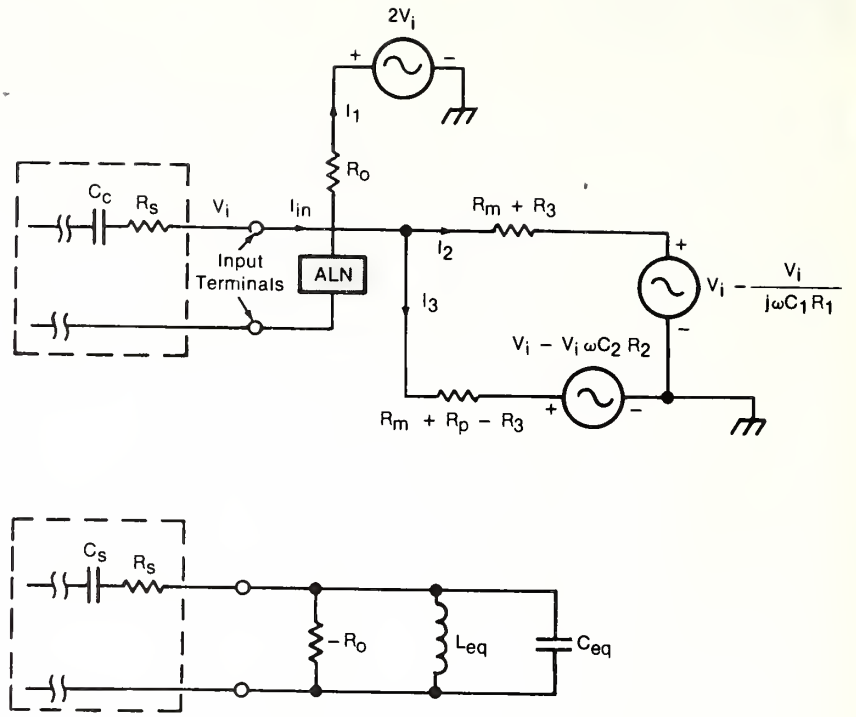


Figure 2. These **Equivalent Circuits** have the same input characteristics as those of Figure 1. The input admittance exhibits a resonance at the resonant frequency of synthetic reactive elements C_{eq} and L_{eq}.

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NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Licensing Opportunity

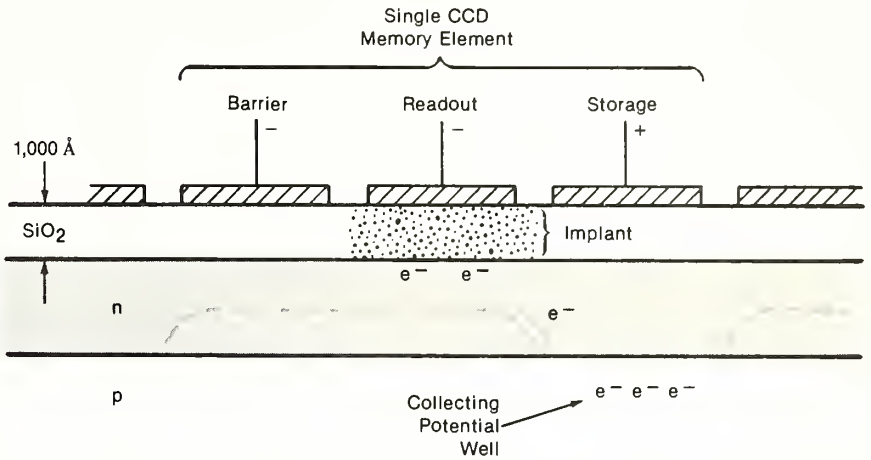
CCD Memory

A CCD memory device yields over 6.4×10^8 levels of information on a single chip.

A charge-coupled device (CCD) has been demonstrated to operate as either a read-only memory (ROM) or a photon-programmable memory with a capacity of 640,000 bits, with each bit capable of being weighted to more than 1,000 discrete analog levels. Larger memory capacities are now possible using the proposed approach in conjunction with CCD's now being fabricated, which could yield over 4×10^9 discrete levels of information on a single chip.

The figure shows a cross section of a single memory element (1 out of 640,000), which is implemented in the ROM mode. Information is programmed into the memory cell beneath the readout electrode by a shallow implant formed within the SiO_2 layer. When the electrode is biased negatively (beyond where the n-channel inverts), a leakage current proportional to the implant dose flows through the oxide. The signal charge is then collected into a potential well located beneath a storage electrode and confined by a barrier gate. This process requires about 100 μs and occurs simultaneously in all 640,000 CCD elements. The information contained in each cell for the entire CCD array is then read out by clocking the gates in the normal CCD fashion to an output amplifier.

The CCD memory can also be programmed by exposing each memory cell to an intense light pattern, which also causes the conductivity to change within the SiO_2 layer proportionally to the incoming photon flux. The programmed information can be read out, as described above, several times before the memory requires refreshing.



A CCD Memory Cell (1 out of 640,000) is programmed by ion implantation within the SiO_2 layer beneath a readout gate. When the gate is negatively pulsed, leakage current proportional to the implant dose flows into the n-channel. The signal charge is then collected beneath a storage gate and later clocked and transferred in a normal CCD fashion to an output amplifier.

This work was done by James R. Janesick, Tom Elliot, Dave Norris, and Fred Vescelus of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 72 on the TSP Request Card.*

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C 2457(f)], to the California Institute of Technology. Inquiries concerning licenses for its commercial development should be addressed to

California Institute of Technology
E. O. Ansell,
Director Patents and Licensing
307 Keith Spalding Bldg.
Pasadena, CA 91125

Refer to NPO-16150, volume and number of this NASA Tech Briefs issue, and the page number.

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NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Controller for a High-Power, Brushless dc Motor

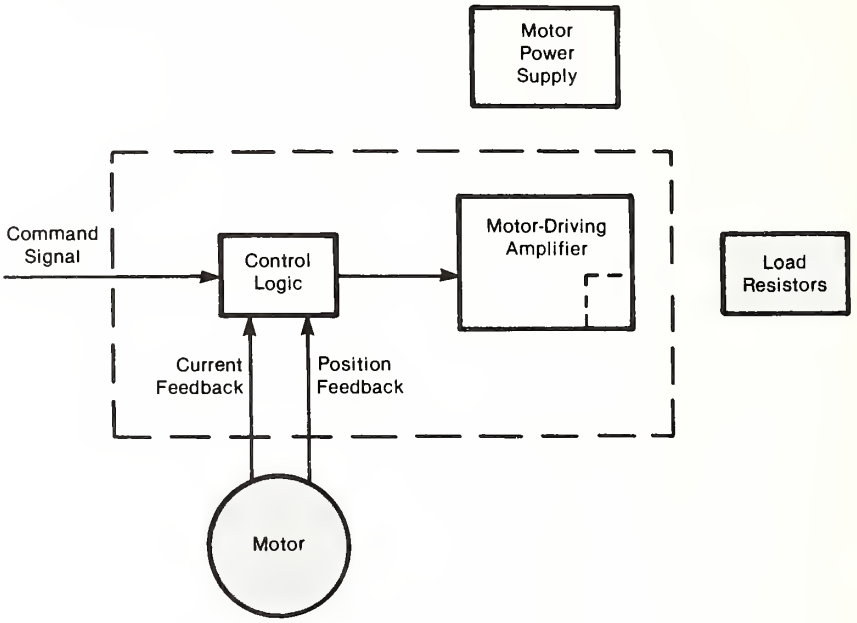
Driving and braking torques are controllable.

A control circuit operates a 7-kW, 45-lb-ft (61-N-m), three-phase, brushless dc motor in both the motor and generator modes. In the motor mode, energy from a power source is pulse-width modulated to the motor through a modified "H-bridge" circuit. In the generator mode, the energy from the motor is pulse-width modulated into a bank of load resistors to provide variable braking torques. The circuit provides high-resolution torque control in both directions over a wide range of speeds and torques and has been tested successfully at bus voltages up to 200 Vdc and currents up to 45 A.

The control circuit includes control logic, a motor-driving amplifier, rotor-position feedback, and motor-current feedback (see figure). The control logic accepts pulse-width modulation data from an outside source (typically a computer) and commands the motor-control amplifier to apply to the motor a voltage proportional to the commanded pulse width. Hall-effect sensors on the motor provide rotor-position data, and the control logic selects the appropriate amplifier leg. Hall-effect current sensors provide the current feedback necessary to limit the motor current to prevent overstress of the bridge amplifier circuit and excessive torques on devices driven by the motor. Signals from the current sensors are conditioned and fed back to the control logic.

The control logic consists of command-decoding logic, pulse-width-modulation-generating logic, and motor-commutating logic. The control logic accepts parallel command data from the computer and commands the selected legs of the bridge to turn on. It also controls the routing of power to or from the motor through large power relays.

The motor-driving amplifier is a modified "H-bridge" with 10 power metal-oxide/semiconductor field-effect transistor (MOSFET) devices in parallel in each leg.



The **Control Circuit** channels the flow of electrical energy among the power supply, motor, and load resistors in a way that enables high-resolution torque control in both directions over a wide range of speeds and torques.

Driving each group of 10 power MOSFET's is an optically isolated, high-current (3-A peak) predriver.

In the motor mode, the bridge circuit pulse-width modulates the bus voltage to the motor until the current reaches a steady-state or current-limit value. If the current reaches the current-limit value, the limit circuit turns off the upper bridge leg until the current decays below this value. The upper leg is then allowed to turn on again. This on/off cycle continues and maintains the current at the limit value.

In the generator mode, the motor current is pulse-width modulated through one or more of three external resistors selected in parallel. The alternate, high-current path is a short across the motor, provided by the bridge circuit. The alternation between the short and resistive paths provides for the control of the braking torque via the control of the pulse width. The use of several external load resistors is necessary to achieve proper torques without overstressing the bridge electronics.

This work was done by David J. Fleming and Terence A. Makdad of Martin Marietta Corp. for **Marshall Space Flight Center**. *MFS-28168 /TN*

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NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Licensing Opportunity

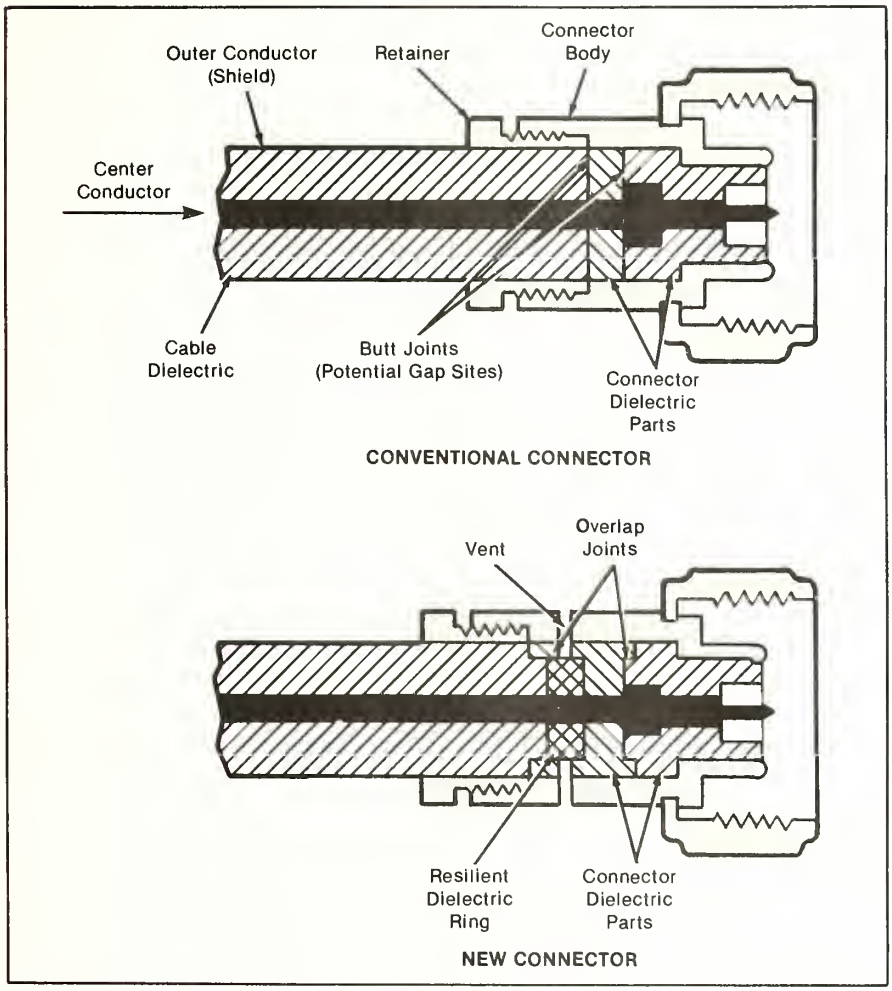
Breakdown-Resistant RF Connectors for Vacuum

Resilient inserts compensate for insulation shrinkage.

A coaxial-cable connector for radio-frequency (RF) energy resists electrical breakdown in a vacuum. The connector can be used on RF equipment in vacuum chambers as well as in spaceborne radar and communication gear.

RF cables and connectors are especially prone to breakdown in a vacuum at power levels of 10 watts or more. This is because coaxial connectors tend to develop gaps between dielectric elements because of thermal expansion and contraction, aging, or manufacturing inaccuracies. RF breakdown can occur wherever a gap develops.

If the pressure in the void is between 0.01 and 0.1 torr (≈1 to ≈10 N/m^2), RF energy can ionize the rarefied gas, and the ionization can form carbon tracks that lead to electrical failure. If the pressure in the gap is about 0.001 torr (≈0.1 N/m^2) or less, multipactor breakdown can occur. This breakdown is a secondary-electron-resonance phenomenon that happens only with RF energy in a vacuum. It rapidly develops into ionization and electrical failure.



Old and New Coaxial Connectors are compared in cross section. The resilient dielectric ring fills the gap created by the lengthwise shrinkage of the cable dielectric. The overlap joints eliminate straight paths between the center conductor and outer conductor. The vent allows trapped air to escape.

In the new connector, a resilient dielectric ring is placed between the solid dielectric pads on the connector and the insulation in the cable (see figure). The ring is slightly compressed (by about 50 percent of its thickness) in the assembled connection. Thereafter, shrinkage of the cable dielectric is taken up by expansion of the resilient ring so that a gap is not allowed to develop in the connector. Two types of silicone rubber dielectric compounds, RTV 3110 and 566, were tested for this application with excellent results.

As a further precaution, the butt joint between the solid dielectric parts in the connector is replaced by an overlap joint. This type of joint eliminates a straight-line path between the center conductor and outer conductor of the connector assembly to inhibit multipactor breakdown.

This work was done by Edward R. Caro and Walter J. Bonazza of Caltech for **NASA's Jet Propulsion Laboratory**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL. Refer to NPO-16764 /TN

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NASA Tech Brief
National Aeronautics and Space Administration

Licensing Opportunity

More Abstracts on Effects of Radiation on Electronic Devices

A previously published bibliography is augmented.

A second volume of a bibliography summarizes the literature on radiation effects on new electronic devices. Like the first volume, the second covers material published in the period 1984–85. The radiation effects include those of protons, electrons, neutrons, gamma rays, and cosmic rays at energies up to about 20 GeV.

The second volume contains 219 abstracts from unclassified sources. The abstracts are organized into four sections: (1) dose-rate effects, new technology, post-irradiation effects, and test environments.

Usually, the type of device to which an abstract applies is identified; for example, complementary metal/oxide semiconductor transistor, metal/semiconductor field-effect transistor, or surface-barrier detector. Where the original abstract is lengthy or vague, it has been condensed or modified for inclusion in the bibliography, to maximize its utility for radiation test engineers.

This work was done by Frank L. Bouquet of Caltech for **NASA's Jet Propulsion Laboratory**. *"Bibliography of Total Dose Radiation Effects on Electronics, Volume II",*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA's Resident Office-JPL Refer to NPO-16959/TN

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REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Ensuring Fully Soldered Through Holes

A vacuum draws solder into holes, even in thick circuit boards.

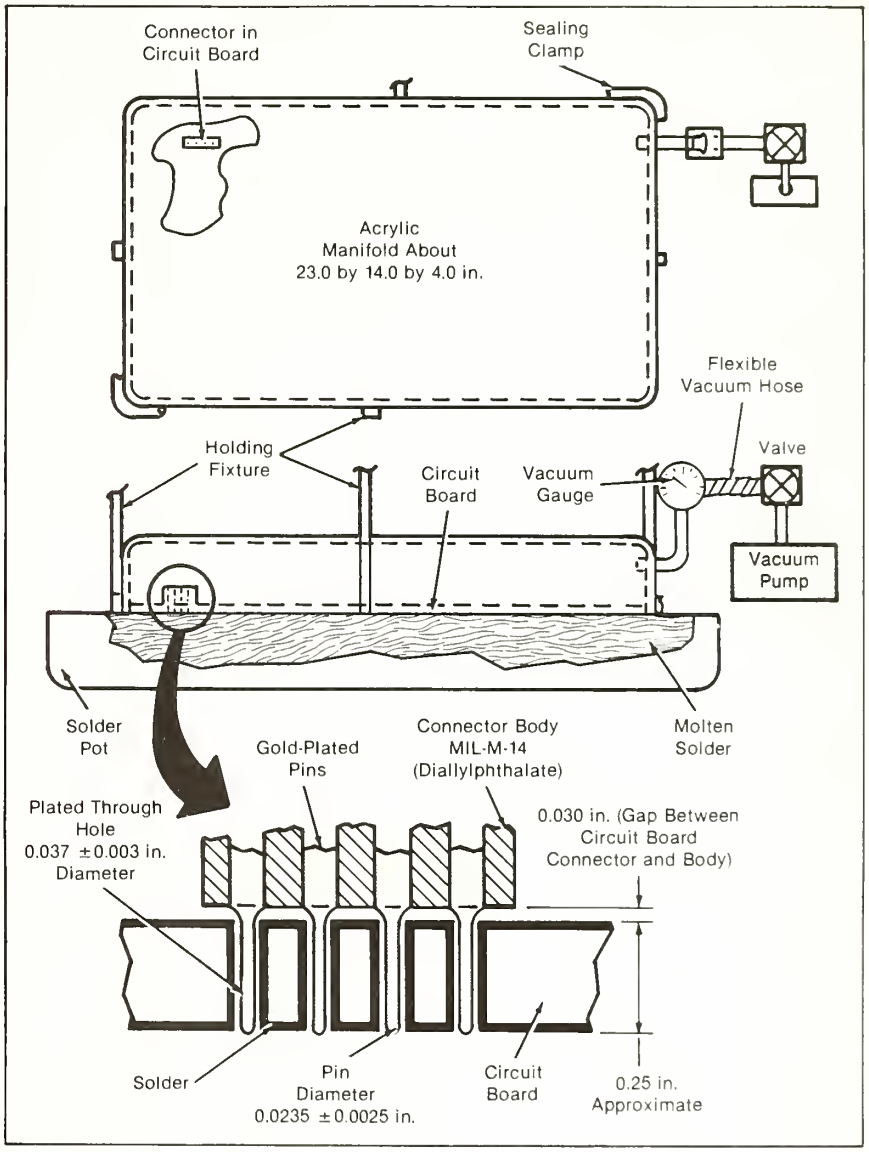
A simple differential-pressure soldering method provides visual evidence that hidden joints are fully soldered. The method is intended for soldering connector pins in plated through holes in circuit boards.

Such conventional methods as hand soldering, wave soldering, and vapor-phase soldering do not allow visual inspection of the joints under the connector body. There is no way of ensuring that the solder has completely wet the through holes. In fact, in wave-soldered circuit boards of 0.187 in. (4.75 mm) or greater thickness, destructive testing by microsectioning shows that full wetting is unlikely: usually, only 30 to 40 percent of a through hole contains solder. The new method, in contrast, gives positive evidence of at least 90 percent filling (as shown by tests of sampling holes adjacent to the connector holes).

A clear acrylic vacuum manifold is placed on the component (upper) side of the assembled circuit board, and its periphery is sealed to the board (see figure). The circuit board is preheated to 300 °F (149 °C), then is held in contact with a bath of solder. The board is allowed to stand on the solder for about 20 seconds, after which a slight partial vacuum is applied to the manifold. The pressure difference draws the solder up into the through holes.

The board is removed from the solder and allowed to cool while the partial vacuum is maintained. The top surface of the board can be viewed through the manifold. The appearance of the sample inspection holes next to the connector will indicate whether the solder has flowed through the holes to the solder pads on the top of the board and has shrunk back into the holes in an acceptable manner.

It is intended to use the differential-pressure process to solder components to an 18-layer board 0.200 in. thick, 21.9 in. long, and 12.8 in. wide (0.5 by 55.6 by 32.5 cm); about 10,200 solder connections on the board cannot be directly inspected. The process is expected to be usable on boards as much as 0.375 in. (9.5 mm) thick.



Molten Solder Flows Into Plated Through Holes, drawn by the vacuum in the manifold over the circuit board. The differential-pressure process ensures that the solder wets the entire through hole around a connector pin.

This work was done by Raymond K. Blow of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29120 /TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
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Energy

1166 Ground-Coupled Heat Pump Models — Three tested models have been developed

1167 Cooling With Ventilation — An overview of design guidelines for residential and nonresidental buildings

1168 Design Principles for Nickel/Hydrogen Cells and Batteries — New designs should prolong cell life. (Licensing Opportunity)

1169 Alkali Metal/Salt Thermal-Energy-Storage Systems — Systems would couple high energy-storage density with minimal corrosion and thermal ratcheting.

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1173 Process for Removal of Hydrogen Sulfide Industrial Gases From Gasified Coal

Ground-Coupled Heat Pump Models

Three tested models have been developed

Ground-coil heat pump (GCHP) systems have long been regarded as having excellent potential for both reduced peak load and energy conservation. Past research work has provided a rich resource of useful test data and experience. However, it is also generally recognized that the development of modeling techniques for the GCHP has remained relatively stagnant for the past three decades.

Ground-coil design is still based mainly on the application of line-source theory, which requires the specification of line-source strength, which has to be estimated. This method works well for those areas in which there have been previous installations and operating experience. In other instances, this method tends to significantly overdesign the ground coil. With other air-conditioning systems becoming more efficient, this practice of excessive overdesign definitely will adversely impact the GCHP's economic competitiveness. It is clear that new models to more realistically describe ground-coil operation are needed for future ground-coil design.

The ORNL ground-coil program began in 1980. The fundamental concept was to be more rigorous in the theoretical analysis underlying development of mathematical models for different types of ground coils. Only through the understanding of heat and mass transfer mechanisms between fluid flow, the coil wall, and the soil can important design factors, many of them ignored by the line-source approach, be studied.

In a report, three horizontal ground-coil models are presented: (1) a horizontal single coil with a radially symmetrical temperature profile and soil moisture freezing effect; (2) a horizontal single coil with nonsymmetrical soil temperatures around the coil; and (3) horizontal double coils, one on top of the other in the same trench, with nonsymmetrical soil temperatures around the coils and with thermal interference effects.

Model 1 is designed to check the effect of soil moisture freezing around the coil. Parametric studies utilizing this model revealed that unless the coil inlet fluid temperature is much lower than the soil moisture freezing point, the amount of latent heat released will be very small compared with the total energy absorbed by the coil. Model 2 enables simulation of the effect of ground surface heat transfer with the ambient air. Model 3 is used to study the effect of two coils being buried in the same trench. It is concluded from field experimental results that this arrangement will absorb about 50% more energy from the ground over a single coil for the same trench length, thus reducing trenching cost.

All three models have been well validated with the field experimental data provided by Brookhaven National Laboratory and The University of Tennessee. The average error of simulating the daily energy absorbed from the ground is only 16%, on the conservative side, from the measured values. It is not possible to compare the ORNL models to line-source models on the basis of energy absorption/rejection because this parameter is

required input for line-source models. Comparison on the basis of predicted ground temperatures, however, reveals that ORNL models match the data better in spite of the fact that line-source models are given the exact heat rejection/absorption rate as input. Considering the application of line-source theory, which cannot accurately assess the level of overdesign or underdesign of ground coil, ORNL models are at least one step ahead.

Computer codes for the three models are listed in the report. The codes are easy to use and do not require the knowledge of solving partial differential equations. All codes are available on floppy disks for personal computer (PC) application or on tape for mainframe computer application.

Although these models simulate much more realistically ground-coil operation than the traditional line-source applications, they also require much more computer time to simulate coil operation. Therefore, at present, these models are probably more suitably used as references by which to check the coil designs based on the line-source method. However, with anticipated improvements in PC speed, these models should be more practical for coil design purposes in the future.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.
NTIS order number: DE87-004051/NAC
Price code: A07
To discuss this effort further, contact:
Dr. V. C. Mei
Oak Ridge National Laboratory
Oak Ridge, TN 37831

Cooling With Ventilation

An overview of design guidelines for residential and nonresidential buildings

Research addressed the design of buildings using solar technologies integrated with air-conditioning to meet cooling needs in climates that seasonally experience both high temperatures and high humidity. Low-energy envelope design strategies that complement air-conditioning were emphasized. The effort deals primarily with detached single-family residences, although the principles are applicable to multistory apartment and condominium buildings and to small office and commercial buildings. Home builders and both present and future homeowners will find the study's results.

Low-energy solutions discussed include natural ventilation, fans, radiant barriers, and window shading. Much is devoted to natural ventilation since this document is an outgrowth of natural-ventilation research funded by the Solar Buildings Technology Program of the U.S. Department of Energy. The data and material, for the most part, are specifically for the Southeast U.S. (North Carolina and southward) because practical low-energy solutions for the heat and humidity of the Southeast are limited to the techniques discussed here, although other approaches are under study. In the Southwest, many other solutions (e.g., evaporative cooling and high-mass buildings coupled with night ventilative or radiative cooling) are possible in addition to those discussed here.

A set of recommendations to homebuilders in hot and humid climates is provided in a final report. Each recommendation is derived from more detailed information in following chapters, and guidance to the chapter that discusses the subject is provided.

Cooling problems are different from heating problems; the sun is a liability rather than a benefit. East and west building sides receive low-angle direct sun and are more difficult ot shade than north or south sides. Cooling load sources and strategies to reduce them also are discussed. Considerable material on radiant barriers and overhangs is presented in this chapter. Guidelines are provided for selection and use of ceiling fans, the most energy-efficient and cost-effective strategy in the Southeast.

Natural ventilation is fully discussed. Emphasis is on understanding airflow in and around buildings so that building protrusions can be used to take advantage of the wind to improve ventilation. complete floor plans of some well-ventilated houses are presented, and innovative ventilation schemes that involve roof-level apertures are discussed. The use of a whole-house fan is described.

Throughout the report, material that should be of particular interest to professional home builders has been highlighted. The main text is followed by a reference section, a bibliography, and two appendices. Appendix A provides a sizing method for windows to attain a given airflow rate through a house. Appendix B provides average wind-related data for selected cities in the southern Gulf and southeastern Atlantic coast states of the U.S.

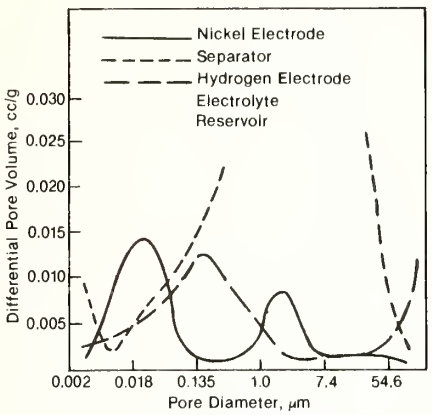
FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.
NTIS order number: DE86-010701/NAC
Price code: A05

NASA Tech Brief
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

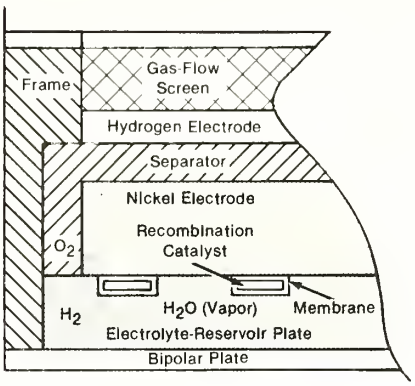
Licensing Opportunity

Design Principles for Nickel/Hydrogen Cells and Batteries

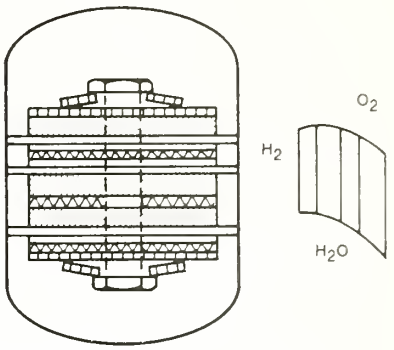
New designs should prolong cell life.



PORE-SIZE ENGINEERING FOR ELECTROLYTE MANAGEMENT



ALTERNATE SITES FOR RECOMBINATION AID THERMAL AND OXYGEN MANAGEMENT



BELLEVILLE WASHERS AND COMPRESSIBLE BIPOLAR ELECTROLYTE-RESERVOIR PLATES ACCOMMODATE NICKEL-ELECTRODE EXPANSION

The **Application of Design Principles for Ni/H_2 Cells** is based partly on previous experience and partly on extrapolations of fundamental principles. The new designs should result in longer cell life at deep discharge.

Individual-pressure-vessel (IPV) nickel/hydrogen cells and bipolar batteries are being developed for use as energy-storage subsystems for satellite applications. The design principles that have been applied to these systems draw upon extensive background in separator technology, alkaline-fuel-cell technology, and several alkaline-cell technology areas. These principles are rather straightforward applications of capillary-force formalisms, coupled with the slowly developing data base resulting from careful post-test analyses. They are based on preconceived assumptions relative to how these devices work and how they might be designed so that they display longer cycle lives at deep discharge.

The basic nickel/hydrogen cell consists of a gas electrode for the anode, a separator to form an ionic bridge to the cathode, and the cathode consisting of nickel hydroxide that is contained within the pores of an electrically conductive substrate. In addition to these basic components, there is a wide variety of options for other components that assist in electrolyte and oxygen management.

The types of shortcomings that are currently associated with nickel/hydrogen devices can be divided into two categories. The first category includes those that are obvious, based on the results of post-test analyses, in cases where failure had occurred, such as the following:

- Unaccommodated cathode expansion;
- Uncontrolled recombination of hydrogen and oxygen;
- Unreplenished loss of electrolyte within the components; and
- Component performance degradation.

The second category includes those decay processes that have not yet been identified as failure modes due to the rapid loss of performance of the device because of the first type of decay processes. The design principles employed address both classes of decay modes.

By applying design principles to nickel/hydrogen cells and batteries in the areas of oxygen management, electrolyte management and reservoiring, and thermal management and component-growth management techniques, designs and/or design modifications have been proposed for both IPV and bipolar cells and batteries. Some of the design modifications (see figure) that have come about as a result of applying these design principles to Ni/H_2 devices are summarized below:

- Oxygen management and thermal management are aided by the incorporation of alternate recombination sites. Recombination is removed from the surface of the hydrogen electrode to remote sites adjacent to a cooling surface. This protects the hydrogen-electrode surface from damage resulting from uncontrolled recombination and aids in thermal management by moving the site of the heat generation for the recombination reaction adjacent to a cooling surface.
- The principles of pore-size engineering have been applied to component designs to insure that the proper distribution of electrolyte exists within the components throughout the life of the cell. Reservoirs incorporated into both designs provide electrolyte to the cells as needed.
- Nickel-electrode expansion is accommodated in both Ni/H_2 designs. In the IPV cells, Belleville washers are incorporated

at both ends of the stack core. They are designed to be compressed as the nickel electrodes expand. In bipolar cells, a compressible reservoir provides this function. These modifications should satisfy some of the needs of the nickel/hydrogen system and ultimately lead to performance and life improvements.

This work was done by Lawrence H. Thaller, Michelle A. Manzo, and Olga D. Gonzalez-Sanabria of **Lewis Research Center**. *Further information may be found in NASA TM-87037 [N85-31646/NSP], "Design Principles for Nickel-Hydrogen Cells and Batteries."*

Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, [A02]

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Lewis Research Center
Refer to LEW-14369 /TN

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NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Alkali Metal/Salt Thermal-Energy-Storage Systems

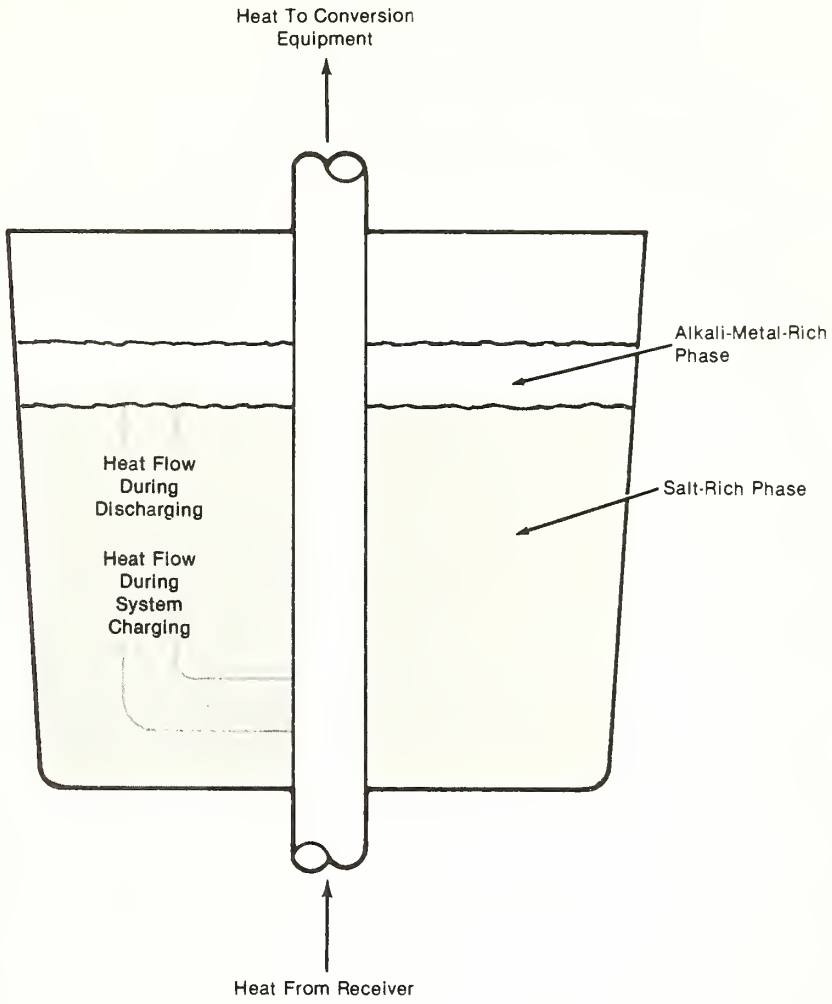
Systems would couple high energy-storage density with minimal corrosion and thermal ratcheting.

A proposed thermal-energy-storage system is based on a mixture of an alkali metal and one of its halide salts; the metal and salt form a slurry of two immiscible melts. The use of the slurry is expected to prevent the incrustations of solidified salts on heat-transfer surfaces that occur where salts alone are used. Since these incrustations impede heat transfer, the system performance should be improved.

Designed specifically to be coupled with solar-thermal-power systems, this system would allow heat to be stored at times of maximum brightness and delivered at times of maximum demand. In terrestrial applications, density differences would produce stratification, with the alkali-metal-rich phase floating on the denser, salt-rich phase. The salt should solidify at the interface between the two melts. Release of the heat of fusion of the salt will boil the alkali metal. The alkali-metal vapor will condense on heat-transfer surfaces and, because of its high purity, will dissolve any salt deposits from these surfaces while releasing its heat of vaporization. The heat-transfer surfaces will thus be kept clean, maintaining efficient heat transfer. If the density of the solid salt is sufficiently larger than that of the salt-rich melt, it will sink to the bottom of the container. This will keep molten salt at the interface between the alkali-metal-rich phase and the salt-rich phase, allowing the process to be continuous.

At the operating temperatures of some Brayton systems [1,500 °F (816 °C)] and Stirling systems [1,160 °F (627 °C)], sodium and potassium have enough vapor pressure to function effectively as heat-pipe fluids. To obtain a reasonable amount of pseudo heatpipe heat transfer, around 400 °C for organic Rankine applications, the alkali metal must be cesium, or else the system must be designed to be charged at higher temperatures where sodium is an effective fluid for heat transfer. Cesium salts form eutectics above 400 °C with many of the lithium, sodium, and potassium compounds considered for Brayton and Stirling applications.

As shown in the figure, the same heat-transfer surface or loop would both charge and discharge the storage system. The boiling and condensation of the metals could eliminate hot spots during charging. Under microgravity conditions, a single distinct interface will not exist, and capillary forces coupled with stirring and pressure differentials produced by alkali-metal vaporization and condensation will be needed to achieve similar heat transfer.



In The **Thermal-Energy-Storage System**, the charging heat-exchanger surface is immersed in the lower liquid, which is rich in a halide-salt, phase-change material. The discharging heat-exchanger surface is immersed in the upper liquid, which is rich in an alkali metal.

Experiments have been performed to investigate corrosion and thermal ratcheting in metal containers filled with either of two mixtures: the metal/salt mixture was 10 weight percent Na with 90 weight percent NaCl; for comparison, a salt-only mixture of eutectic NaF/MgF_2 was also tested. Each mixture was placed in a capsule of 321 stainless steel or 9Cr/1Mo alloy steel. The capsules also contained tensile tabs, and some contained zirconium getter foils to remove impurities.

Cycling the Na/NaCl system ±150 °F (±83 °C) past the salt melting point 2,600

times during 4,000 hours resulted in moderate corrosion of the 9Cr/1Mo alloy containers but negligible corrosion of the 321 stainless-steel containers. Under the same conditions, the NaF/MgF_2 systems without the sodium addition produced significant corrosion of the 321 stainless-steel containers. The Na/NaCl system did not reduce the tensile strength of the 321 stainless steel, although ungettered samples showed some decrease in yield strength. In contrast, the 9Cr/1Mo alloy showed significant decreases in strength. Thermal ratcheting was not observed in the Na/NaCl slurry system with 321 stainless steel but did occur with the 9Cr/1Mo alloy.

This work was done by Wayne W. Phillips and John W. Stearns of Caltech for **NASA's Jet Propulsion Laboratory**.
NPO-16686 /TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
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Engineering

1170 Diesel Engine Improvements are the Aim of New Thermocouples

1171 Seismic Design Guidelines Issued

1172 Engineering Standards Index

1173 Process for Removal of Hydrogen Sulfide Industrial Gases From Gasified Coal

1174 Improving the Performance of Internal Combustion Engines Through Controlled Combustion

1175 Large Deployable Shroud — Deployable masts would extend lightweight fanfolded panels. (Licensing Opportunity)

1176 Cascaded-Blackbody Heat Radiators — Textured fins increase the effective emissivity.

1177 Forced-Flow Evaporative Cooler — Centrifugal force maintains thermal contact in unusual gravitational conditions. (Licensing Opportunity)

1178 Blender for Antimisting Kerosene — A demonstration unit meters polymeric additives into jet fuel during refueling.

1179 Active Suppression of Rotor Vibrations — A feedback system enables operation at and beyond critical speeds.

1180 Emergency Control for a Circulation-Control Helicopter Rotor — A digital system gives the pilot partial command when the primary system fails. (Licensing Opportunity)

1181 Refrigerator Based on Chemisorption — A reversible chemical reaction would generate pressurized oxygen for cooling. (Licensing Opportunity)

1182 Extinguishing Fuel-Leak Fires in Jet Engines — Potassium dawsonite and several other chemicals are effective in delaying reignition. (Licensing Opportunity)

Testing & Instrumentation

1183 Overview of Fiber-Optical Sensors — The design, development, and sensitivity of sensors using fiber optics are reviewed.

Other items of Interest

1209 Theory for NDE Technique to Detect Flaws in Concrete

1383 Vibration in Advanced Helicopter Transmissions — Acoustic behavior of a new gear train and housing are evaluated.

NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Diesel Engine Improvements are the Aim of New Thermocouples

More efficient and longer-lasting diesel engines may result from the application of a-new type of thermocouple device developed at NBS that monitors critical internal temperatures of these engines. Researchers at the bureau's Center for Chemical Engineering are experimenting with "thin films" of noble, chemically inactive metals such as platinum and gold. Unlike traditional wire thermocouples, these films are deposited directly onto engine parts and act as sensors to indicate temperature at those points. By having accurate temperature measurements during operation of such diesel engine components as valves, cylinder heads, and piston crowns, it is possible to monitor wear and tear of engine hardware as well as provide input for controlling automatic engine functions such as fuel-air mix and timing. Temperature data also are important in the design phase of modern ceramic-coated diesel engines for decisions such as how thick the engine's insulating ceramic coating should be or what porosity the coating should have. NBS is working with researchers from Purdue University, the Department of Energy, and the National Aeronautics and Space Administration to test the thin-film technology in a ceramic diesel research engine.

Researchers at the NBS Center for Chemical Engineering are experimenting with "thin films" of noble, chemically inactive metals such as platinum and gold, which are fashioned into scaled-down thermocouples. Unlike traditional wire thermocouples, thin films are deposited directly onto engine parts and act as sensors to indicate temperature at those points.

By having accurate temperature measurements during operation of such diesel engine components as valves, cylinder heads, and piston crowns, it is possible to monitor wear and tear of engine hardware as well as provide input for controlling automatic engine functions such as fuel-air mix and timing.

Temperature data also are important in the design phase of modern ceramic-coated diesel engines. For example, knowing how hot the combustion chamber of an engine gets during operation allows design engineers to decide how thick the engine's insulating ceramic coating should be or what porosity the coating should have.

Much of the NBS work to date--which is supported by the Department of Energy--has focused on problems that interfere with successful operation of the films. One of these has been a difficulty with electrical shorts through the material that insulates the film from the surface of engine parts. Poor adhesion of the thin film to the insulator can cause difficulties as well.

A double-oxide layer has been developed that includes a thermal oxide and a sputterdeposited oxide which have the best electrical insulating properties at 2000 degrees Fahrenheit. This material insulates platinum and other metals at engine temperatures and provides improved adhesion.

Thin films have many advantages over traditional wire thermocouples. These older devices--basically two wires of dissimilar metals joined at both ends which

indicate temperature by measurement of the voltage difference between the two ends-tend to be cumbersome for diesel engine applications. Because the wire devices must be imbedded in machined grooves inside engine parts, they create obstructions. This can lead to distortions in reproducing exact heat transfer conditions.

Thin films, on the other hand, use the same principle as wire thermocouples, but typically are only 2 millionths of a meter thick, so they do not cause these interferences. Temperature measurements by means of voltage readings can be made with a voltmeter outside the engine, or perhaps in the future through a readout on a vehicle dashboard.

Thin films have other advantages:

- They conform to complex surfaces, making them adaptable to a variety of locations inside engines.
- Multiple installation is easy and inexpensive. Though metals like platinum and gold are used, such a tiny amount is required, cost is only about $2 per thermocouple.
- Thin film devices have fast response times. o Besides measuring temperature, thin films also indicate heat transfer, or the amount of heat dissipated by engine operation. This is particularly important in developing modern ceramic diesel engines--which have no radiators--because accurate heat transfer is the key to efficient operation of these engines. (These engines have no radiators because research has shown that up to 30 percent of a diesel engine's energy is lost by liquid cooling.)

The NBS work, while showing much promise in laboratory experiments, has moved closer to practical applications. Most notably, it has been used in a ceramic diesel research engine located at Purdue University in Lafayette, Ind. This research, which is also sponsored by the Department of Energy and the National Aeronautics and Space Administration, aims to develop a fuel-efficient, high-performance engine that could be used in vehicles such as trucks, buses, heavy equipment, even military tanks.

Using information from the NBS work, researchers on the Purdue project fashioned a thin film thermocouple that was inserted into the engine's cylinder wall. Initial temperature measuring results were less than desirable, and Kreider says the fault was with the thermocouple itself. He is designing one for Purdue that he hopes will overcome the earlier problems.

The center also has assisted major diesel engine manufacturers such as Cummins, Detroit Diesel, and Caterpillar, which are exploring how they can use thin film technology in their products.

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NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Seismic Design Guidelines Issued

NBS, as secretariat of the Interagency Committee on Seismic Safety in Construction, has issued guidelines for federal agencies to use in designing and constructing buildings to resist earthquake damage. The report was prepared as part of the National Earthquake Hazards Reduction Program. The Guidelines are based on existing voluntary standards, model building codes, and federal regulations. In particular, the technical content is similar to the seismic design requirements of the 1985 Uniform Building Code published by the International Conference of Building Officials. The report includes information on site planning, structural design criteria, structural analysis procedures and design details, as well as design and construction standards for structural materials including steel, concrete, and wood. In addition, it includes nonstructural design requirements, such as protecting against secondary hazards and information on quality control and inspection.

For Additional Information:

The report, *Seismic Design Guidelines for Federal Buildings* (NBSIR 873524), is available from the National Technical Information Service, Springfield, VA 22161. Refer to order number, PB87-161204/NAC price code, A0.

NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Engineering Standards Index

NBS has updated its Key-Word-In-Context (KWIC) Index of U.S. Voluntary Engineering Standards for use by manufacturers, exporters, importers, and others concerned with standards developed by U.S. trade associations and technical and professional societies. The KWIC index contains more than 28,000 titles of standards developed by approximately 400 U.S. standards organizations. First published in 1971, the revised microfiche index provides the title, date, source. and number of the standard for each entry. Each standard can be found under all significant keywords in the title. The date of publication or last revision, the standard number, and an acronym designating the standards-issuing organization appear as a part of each entry.

For Additional Information:

For information on the KWIC index contact the
National Center for Standards and Certification Information,
A629 Administration Building, National Bureau of Standards, Gaithersburg, Md. 20899;
(301) 975-4040

Copies of the KWIC index are available from the National Technical Information Service, Springfield, VA 22161. Refer to order number, PB87-133377/NAC price $29.95 paper copy and $18 for microfiche copy.

Lawrence Berkeley Laboratory

Process for Removal of Hydrogen Sulfide Industrial Gases From Gasified Coal

This is a process for removing hydrogen sulfide (H2S) from gasified coal and recovering the sulfur in an environmentally safe form. Also applicable to other industrial gases, this new process promises to be more flexible and cost effective than current technology. Gas derived from coal contains a significant amount of hydrogen sulfide which must be completely removed before the gas can be used for fuel or synthesis gas. In the process. hydrogen sulfide is absorbed by a solvent and the resulting solution is mixed with sulfur dioxide that has been dissolved in the same solvent. The two sulfur compounds react to form water and elemental sulfur which crystallizes out of the solution after it has cooled. The solvent is a polyglycol ether and can be tailored to meet particular needs.

Why This Is Better Than Existing Technology: Adaptable to meet user's individual needs. Can remove hydrogen sulfide to less than one part per million. Capital cost should be one-third less than present processes.

State of Development: Preliminary studies are complete. Pilot plant study may start in two years.

Potential uses and spinoffs: Applicable to removing H2S from other industrial gases.

Patent Status: Patent Pending

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Berkeley. CA 94720
(415) 642.1634

Documentation:

A Comparison of the UCB Sulfur Recovery Process with Conventional Technology for Treating Recycle Gas From a Crude Oil Residual Hydrotreater (S. Lynn. D.#. Neumann. S.F. Sciarnanna. F.N. Vorhis) Report LBL-21574

Lawrence Berkeley Laboratory

Improving the Performance of Internal Combustion Engines Through Controlled Combustion

This is technology for closely controlling the combustion process in an internal combustion engine. In this development work. an operating condition is sought that is between that of a compact explosive detonation and a connected flame front sweeping across a combustion chamber. The combustion chamber is thereby converted from merely a source of power into a full fledged chemical reactor where the process is maintained under satisfactory control. The desired operating condition can be achieved by multipoint ignition whereby a large set of. elementary flame kernels or exothermic centers are established. so that all the exothermic energy is evolved by the time their fronts merge. A multitude of ignition sources can be obtained by proper flow conditions that provide for recirculation of products. The latter are capable of furnishing active radicals that. upon mixing with reactants. form multipoint ignition sources. Major means of affecting the chemically reacting system in a proper way are fluid mechanical in nature. albeit it is the chemical reaction of combustion that is to be controlled

Why This Is Better Than Existing Technology: Engines that provide for controll!ed combustion should be able to convert fuel into useful work with maximum efficient. minimum pollutant emissions. and optimum tolerance to a wide variety of fuels

Stage of Development: Laboratory testing and modeling to determine basic aspects are in progress.

Potential Uses and Spinoffs: Usage in all types of internal combustion engines.

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NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Licensing Opportunity

Large Deployable Shroud

Deployable masts would extend lightweight fanfolded panels.

A preliminary design has been proposed for a large, lightweight telescope shroud or light shield (see figure) that could be carried to orbit in a single Space Shuttle cargo load. The shroud concept might be applied on Earth in portable, compactly storable displays or projection screens: indeed, the shroud is based in part on an old portable-projection-screen concept.

The shroud comprises four identical units (see figure), each with one deployable mast and two sets of panels that form two adjacent walls of an octagonal structure. In each shroud unit, the deployable mast fits between the two boxes of panels, which are hinged on the mast canister.

While in storage, the boxes are straightened out; for erection, they are held at the proper angle by a four-bar linkage. Snap locks are used to attach the units to each other and to the structural base so that no tools will be required for assembly.

Once the four shroud units have been attached to the base, the shroud can be deployed by operating a switch to initiate the extension of the masts. A strip is also deployed from a roll canister at each corner to block the lines of sight through the gaps between panels. Anti-flapping straps could then be installed manually to connect adjacent walls of the shroud.

This work was done by G. G. Jacquemin of **Marshall Space Flight Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center. Refer to MFS-28173/TN

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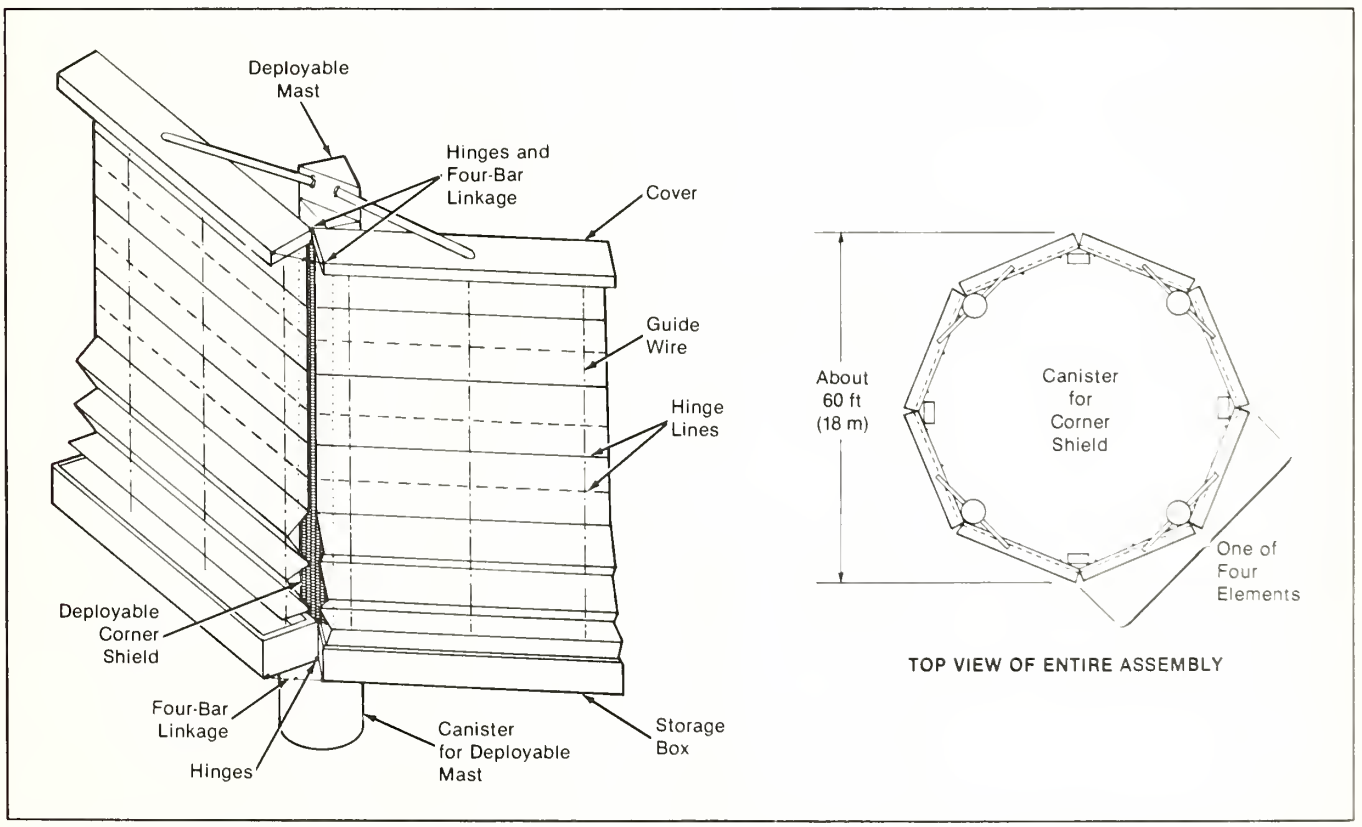

The Large Telescope Shroud includes four deployable masts that erect eight walls of hinged panels of polyimide film. The panels are stored fanfolded before deployment and threaded on guide wires that unwind from spools and remain taut during deployment.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
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NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Cascaded-Blackbody Heat Radiators

Textured fins increase the effective emissivity.

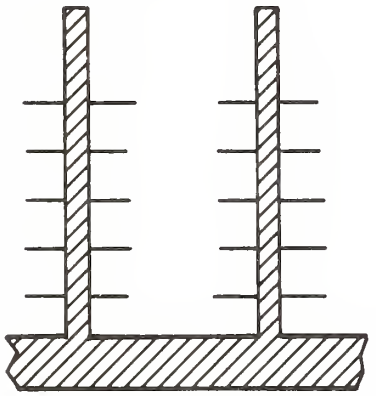

Figure 1. **Fins With Finned Surfaces** form large cavities lined with smaller cavities to produce a cascaded-blackbody effect.

A new class of heat radiators are made of metal or other conductive fin stock, the fins of which are textured or covered with smaller fins (see Figure 1). Measured from the outside, the effective emissivity of a projected radiator surface is greater than, and somewhat independent of, the emissivity of a flat surface made of the same material. Thus, special coatings to enhance emissivity are not required, and the emissivity will not be degraded significantly in the long term by environmental effects. Intended originally to radiate excess heat away from spacecraft, the new radiators can also be used on Earth to dissipate heat in vacuum systems.

With its finned structure, each radiator effectively consists of large cavities, the walls of which are lined with small cavities. In a manner reminiscent of anechoic chambers and conventional "blackbody" furnaces, multiple reflections, absorptions, and reradiations occur on the myriad of cavity walls. Thus, when viewed as a whole, the radiator behaves more nearly like a black body than does a flat surface of the same material. The blackbody effect is enhanced by cascading the effects of the small cavities in the walls of the large cavities.

The radiator surface can be made by bonding metal powder, metal felt, knitted wire, or smaller fin stock to a solid fin-stock substrate. An experimental version was made of composite copper powder on parallel-finned copper stock. For measurements of its effective emissivity, it was placed in a vacuum close to (but not touching) two water-cooled, flat-plate calorimeters and heated electrically. The same test was also performed on two similar radiators, one made of flat copper plate and the other of simple parallel-finned copper stock. As shown in Figure 2, the composite finned radiator performed better than the other two at temperatures from about 200 to 600 °C. The comparison of performance is uncertain at lower temperatures because the specimens underwent some vacuum cleaning when heating began and the first measurements were taken.

For effective heat dissipation, the new radiators must not be allowed to face other heat sources because the same cascaded-blackbody effect that increases the emissivity also increases the absorptivity. Thus, for example, a spacecraft radiator must be pointed away from the Sun and the Earth, and a laboratory vacuum radiator must be pointed toward a cool, absorptive surface.

This work was done by Michael D. Keddy, G. Yale Eastman, and Donald M. Ernst of Thermacore, Inc., for **Marshall Space Flight Center.** *MFS-26033 /TN*

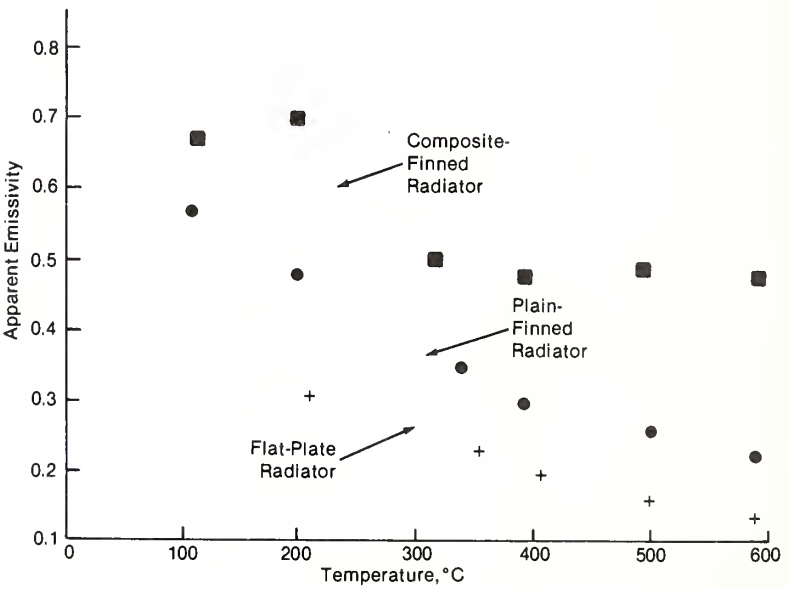

Figure 2. The **Apparent Emissivities** of three radiating surfaces of the same material were measured. The highest emissivity is exhibited by the most highly textured surface.

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NASA Tech Brief
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Licensing Opportunity

Forced-Flow Evaporative Cooler

Centrifugal force maintains thermal contact in unusual gravitational conditions.

An evaporative cooler absorbs heat efficiently under unusual gravitational conditions by using centrifugal force and vapor vortexes to maintain good thermal contact between the heat-transfer surface and the vaporizable coolant. This system would be useful for cooling electronic or other equipment under the low gravity encountered in spacecraft or under the multiple-gravity conditions frequently experienced in high-performance airplanes.

Although evaporative cooling is normally one of the most efficient cooling techniques, ordinary versions of this technique do not work well under unusual gravitational conditions. Under zero gravity, the liquid phase of the coolant floats within its flow path within an evaporator, without necessarily making a good thermal contact with the inner evaporator surface through which heat transfer must occur. In high gravity, the coolant liquid is driven in a particular direction, losing contact with a major portion of the evaporator heat-transfer surface. In both cases, heat-transfer efficiency is decreased.

In one version of the proposed cooling system (see Figure 1), the coolant passes through a conductive tube of rectangular cross section, wound into a flat spiral. The tube is sandwiched between two conductive plates in direct thermal contact with the equipment to be cooled. The coolant enters the tube at the center of the disk and leaves it at the outer edge, or vice versa. In a similar, alternative configuration, the coolant-carrying tube has a reverse bend near the center of the spiral, effectively creating two interleaved spirals. In this configuration, the coolant both enters and leaves on the outside of the disk.

The flow of coolant along the spiral generates substantial centrifugal force. Consequently, the liquid coolant, being denser than the vapor, moves radially outward, pressing against the radially outer wall of the tubing. It has been determined that once liquid coolant strikes the radially outer wall of the tubing, it circulates around the interior of the tubing, covering the entire inner wall (see Figure 2) and thereby providing a high degree of thermal contact.

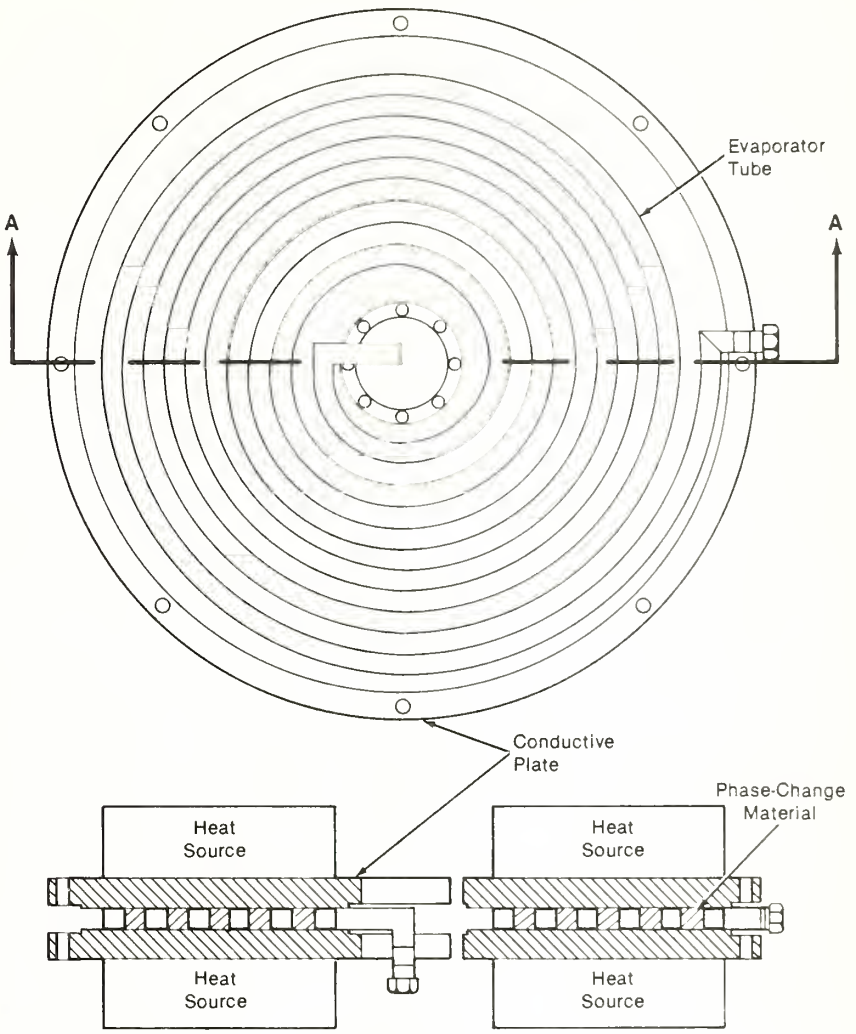

Figure 1. **The Coolant Flows in a Spiral Tube** sandwiched between two plates.

Where the heat input varies during an operating cycle — for example, as a consequence of the turning on or off of one or more electronic circuits being cooled by the system — the space between adjacent coils within the disk and between the conductive plates could be filled with a phase-change material; for example, hexadecane or other paraffinic material. During periods of rapid heat input, this material would melt, absorbing a relatively large amount of heat during a short time. During low heat loads, the material would be solidified by the excess cooling capacity of the

evaporator, thereby regaining its ability to act as a supplemental coolant during high heat loading.

The evaporative cooler could also be used to cool or condense a second heat-transfer fluid. In one version, conduits containing the hot fluid to be cooled are in thermal contact with the conductive plates. Alternatively, hot fluid could be circulated through the channel between the turns of the evaporator tube.

This work was done by Wilbert E. Ellis of **Johnson Space Center** *and Richard E. Niggemann of Sundstrand Corp.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Johnson Space Center Refer to MSC-21078/TN

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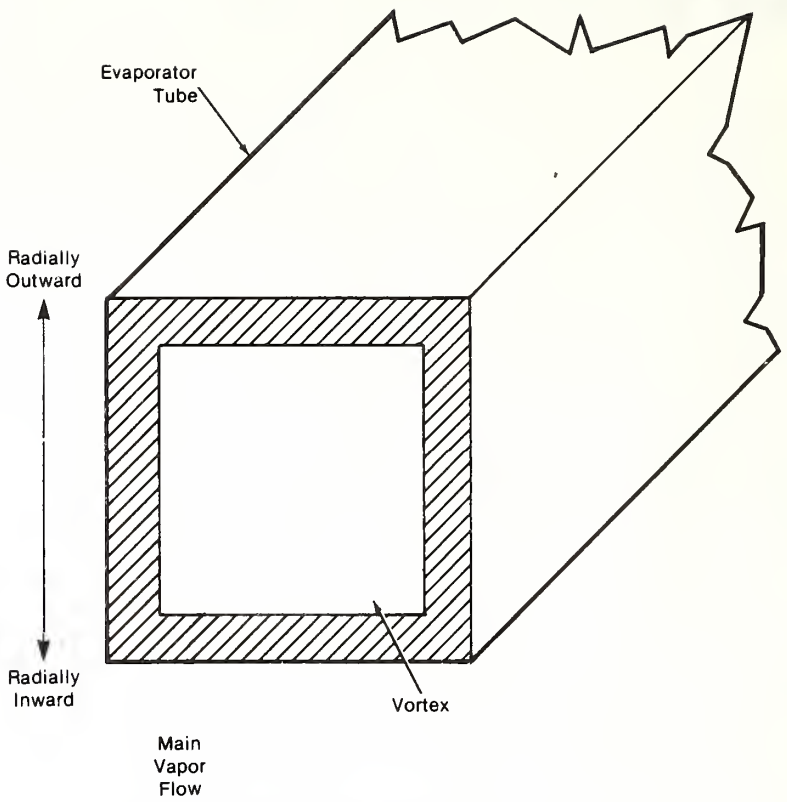

Figure 2. **Liquid Circulates Around the Inner Tube Surface**, driven by counterrotating vapor vortexes. This flow regime is aided by a relatively rapid flow of vapor-phase coolant through the tubing; this vortex-creating mechanism is particularly important in the case of high gravitational loads.

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NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Blender for Antimisting Kerosene

A demonstration unit meters polymeric additives into jet fuel during refueling.

A blender continuously disperses a controlled amount of flammability-reducing additive into a stream of jet fuel. The resulting mixture consists of a homogeneous suspension of additive polymer particles in the fuel. The particles dissolve within 15 to 30 min, without agitation, forming the airplane fuel known as antimisting kerosene, which promises to reduce the danger from fire in crashes.

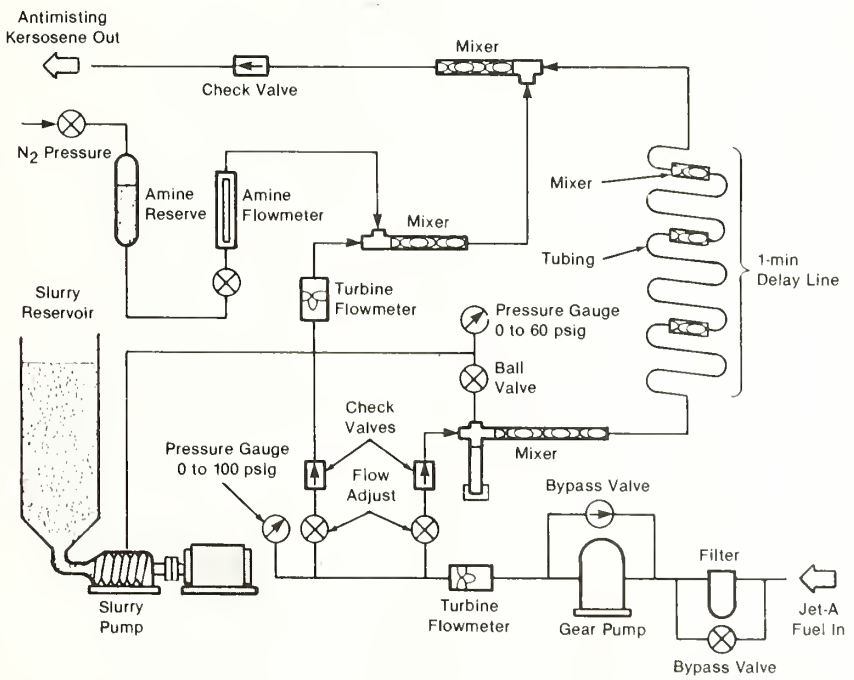
The blender delivers up to 10 gal/min (0.6 L/s) of the liquid mixture. It was developed as a demonstration of the mixing concept and as a source of fresh antimisting kerosene for laboratory experiments. The apparatus can readily be enlarged to provide mixing at an aircraft-fueling site — the delivery mode envisioned for worldwide use of antimisting kerosene.

The apparatus consists of subsystems for pumping and metering the jet fuel, for pumping and metering the additive (a polymer slurry), and for injecting the additive into the fuel (see figure). A gear-type fuel pump was chosen because it delivers a smooth flow and is insensitive to changes in the inlet and exit pressures. It is driven by a variable-speed motor. A turbine flowmeter downstream from the gear pump provides a series of pulses with a repetition frequency proportional to the flowrate.

The additive is pumped by a rotary screw especially suited for slurries. It is powered by a speed-controlled motor through a 20:1 speed-reducing gearbox. A flexible hose delivers the slurry from the pump to the slurry-injection tube. The slurry flow is calibrated as a function of the motor speed and the pressure just upstream of the injection tube.

It is important that the slurry particles be dispersed in the fuel immediately after injection. Otherwise, blobs of slurry form, leaving the fuel with reduced flammability protection. Accordingly, an inline static mixer is positioned just downstream of the injection point. The mixer has no moving parts but contains helical elements that direct the flow alternately clockwise and counterclockwise. The mixing-tube diameter is selected to provide a Reynolds number high enough for effective mixing (5,000 to 30,000) without excessive pressure drop [10 lb/in.^{2} (70 kPa) maximum]. Additional mixers are placed downstream.

Optionally, the blender also mixes a metered amount of amine into the polymer/fuel suspension about 1 min after the polymer has been injected, because experiments show that the delayed amine injection enhances the dissolution of the additive in the fuel. The delay line is a tube 120 ft (36 m) long of 1-in. (2.5-cm) diameter, with static mixers placed at 20-ft (6-m) intervals. The amine is dispensed from a pressurized chamber through a needle valve and a rotameter.



The **Blender Combines Three Components**: fuel, polymer, and amine. The amine is first blended with fuel in one leg, then mixed with the polymer/fuel suspension in the other leg far enough downstream that the polymer particles have been in the fuel medium for about a minute. The delay is necessary to bring out the beneficial effect of the amine.

This work was done by Pradip G. Parikh, Virendra Sarohia, and Andre H. Yavrouian of Caltech for **NASA's Jet Propulsion Laboratory**. *NPO-16968 TN*

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NASA Tech Brief
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

Active Suppression of Rotor Vibrations

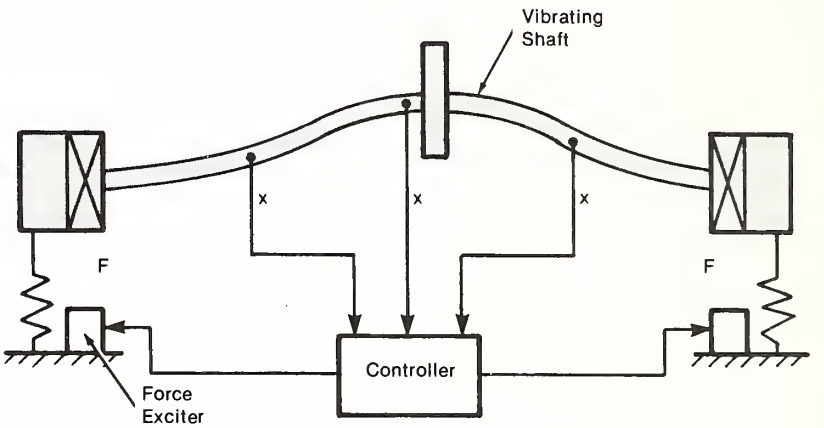
A feedback system enables operation at and beyond critical speeds.

In active rotor control, vibrations of flexibly supported rotors are suppressed by the use of an electronic feedback control system. The feedback control system senses the vibration level of a rotor system and, in turn, provides damping such that vibration level is maintained within acceptable limits. This enables a rotor to operate through and above its critical speeds, increases bearing life, reduces the size and weight of rotating shafts, and generally enables rotors to operate more smoothly.

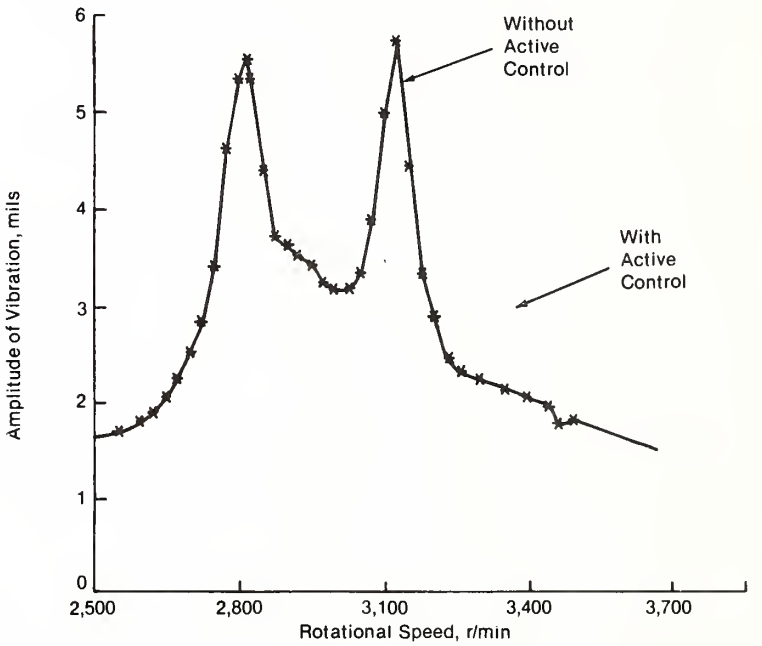
The significant features of the active rotor-control system shown in the figure are the electronic controller and the force exciters. The vibrational velocity ($\dot{x}$) is sensed, and the sensor output is sent to the electronic controller, which processes the velocity signal and commands the force exciters to provide the desired level of damping force (F) to the rotor support (see top of figure).

The electronic controller is programmed by entering feedback coefficients to provide any desired percentage of critical damping. The feedback coefficients are calculated by a computer program and are based on a modal analysis of the vibrating rotor system. Preliminary experiments on the active rotor-control system at Lewis Research Center have demonstrated that a high degree of damping is achievable, as shown at the bottom of the figure.

This work was done by Eliseo DiRusso of **Lewis Research Center**. *No further documentation is available.*
LEW-14488./TN



ACTIVE ROTOR-CONTROL SYSTEM



VIBRATION MEASUREMENTS

The **Active Rotor-Control System** reduces the amplitude of vibration over most of the experimental range of rotational speeds.

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NASA Tech Brief
National Aeronautics and Space Administration
Ames Research Center, Moffett Field, California

Licensing Opportunity

Emergency Control for a Circulation-Control Helicopter Rotor

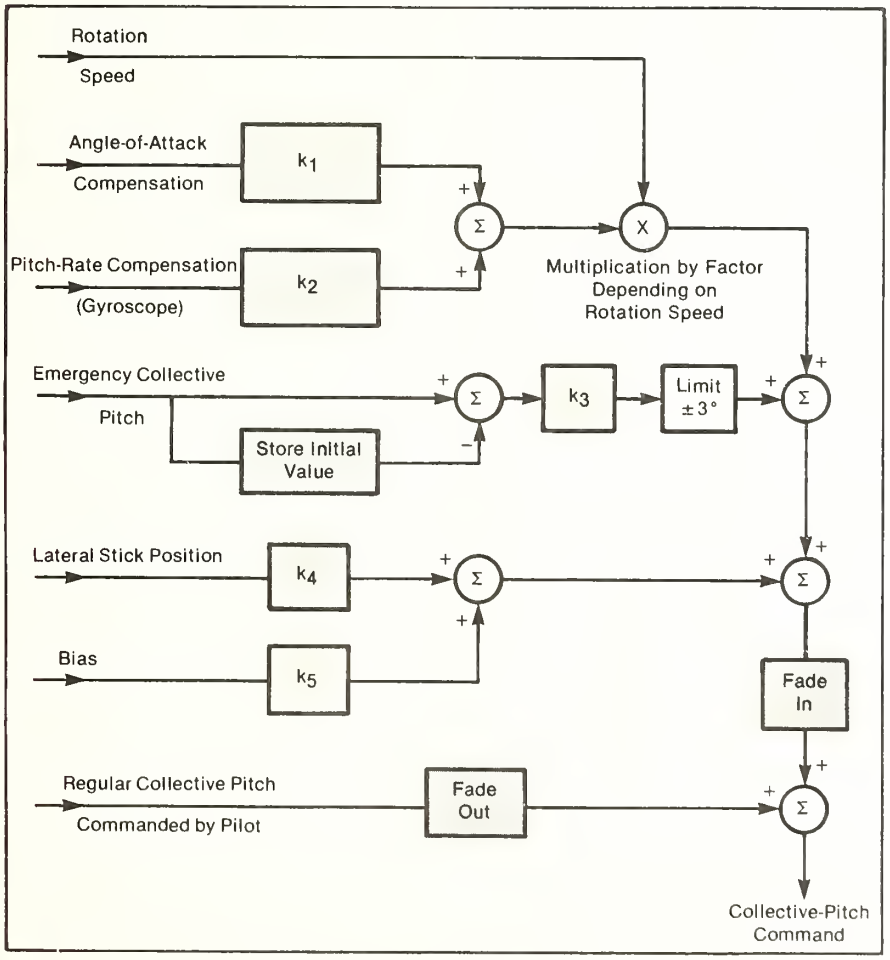
A digital system gives the pilot partial command when the primary system fails.

An emergency system (see figure) provides digital control of a rigid circulation-control rotor for the experimental X-wing aircraft. In addition to centering collective-pitch control, the new command provides limited roll control via collective pitch and gyroscopic decoupling in pitch and aerodynamic decoupling.

The X-wing aircraft uses a rigid, stoppable, circulation-control rotor. In normal operation, lift and the pitch and roll moments on the rotor are controlled by varying the pressure and airflow from the rotor blowing holes. For roll control at higher forward flight speeds and for lift augmentation in hovering, conventional collective-pitch control is used. If the blowing control is lost, the rotating rotor can be a strong source of unwanted pitch and roll moments.

A digital type of backup system was chosen for simplicity and reliability; although an analog system could be built, it would be complicated and less reliable. The backup system is implemented via a second independent software program executed by the same quadruply redundant computers used for the prime system. The Backup Control Software (BUCS) is switched in when selected by the pilot or automatically when the third computer servers. The digital system treats the rotor in its unblown state so that the requisite software is also simple. When the primary control system fails, the emergency system fades out the existing collective-pitch command and fades in a new collective-pitch command. The new command consists of the sum of the collective-pitch bias, lateral-stick-position, angle-of-attack, and pitch-rate signals.

To compensate for changes in the roll moment caused by angle-of-attack changes, the digital backup sends an angle-of-attack signal to the collective-pitch control. To reduce gyroscopic coupling, the system also feeds pitch-rate data to the collective-pitch control. Because both gyroscopic and angle-of-attack effects exist only in the rotary-wing mode the angle-of-attack and pitch-rate signals are amplified according to the rotor speed from zero amplification for a stopped rotor to maximum amplification at full rotational speed.



The **Emergency-Control System** processes the collective-pitch pilot command, lateral-stick-position, angle-of-attack, and pitch-rate signals to generate a new collective-pitch signal that restores neutral lift and partial control of roll and collective pitch.

This work was done by William C. Fischer, Kenneth C. Arifian, and Tom H. Lawrence of United Technologies Corp. for **Ames Research Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center Refer to ARC-11605 /TN

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NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Licensing Opportunity

Refrigerator Based on Chemisorption

A reversible chemical reaction would generate pressurized oxygen for cooling.

A concept for a cryogenic refrigerator is based on the chemical absorption of oxygen by a praseodymium/cerium oxide (PCO) compound. The refrigerator would produce a cryogenic liquid for cooling infrared sensors. The concept could also be used for liquefying air and for separating oxygen from nitrogen in air.

Gaseous oxygen would be compressed in a vibrationless, wear-free, fully reversible reaction cycle. The refrigerator would include two chemisorption compressors, a series of heat exchangers, a Joule-Thomson expansion valve, and a vessel to collect liquid oxygen (see figure). While one compressor is cooled so that it chemically absorbs oxygen at 0.3 atm (30 KPa), the other would be heated so that it releases oxygen at 28 atm (2.8 MPa). The compressors would alternate in heating and cooling. Flowing through the expansion valve, the pressurized oxygen would cool in the collection vessel at a temperature of 60 to 100 K. The boiling liquid oxygen in the vessel would absorb heat from the refrigeration load. Along with some uncondensed expanded oxygen, the boiled oxygen gas would return to one of the compressors.

When cool, PCO would combine with the oxygen flowing over it, forming PCO in a higher oxidation state. When heated to a temperature of 650 °C, the oxygenated PCO would dissociate. The absorbed oxygen would pass off as a gas, leaving the PCO to absorb more oxygen when it is recooled.

On leaving a compressor, the hot oxygen would be cooled to 275 K in a radiator. It would be cooled further by a recuperative heat exchanger and a charcoal/methane sorption refrigerator at 140 K. This would liquefy the high-pressure oxygen and allow efficient expansion to 80 K at 0.3 atm (30 KPa). The oxygen returning to the compressors would pass through the recuperative heat exchangers, absorbing heat from the inflowing oxygen.

The entire refrigerator system would require about 150 W (mostly as heat) to produce 1 W of cooling at 80 K. Although its efficiency would be lower than that of some mechanical units, multistage sorption systems using hydrides are considerably more competitive. With an oxide upper stage, the overall system weight and the power efficiency for closed-cycle solid hydrogen sublimation (7 K - 14 K) are significantly better than those of any other known refrigeration system. Furthermore, there are essentially no wear-related moving parts and thus virtually no vibration. Life expectancy of this JPL-developed refrigeration system is at least ten years and thus ideal for long-life space use.

This work was was done by Jack A. Jones of Caltech for **NASA's Jet Propulsion Laboratory**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, JPL
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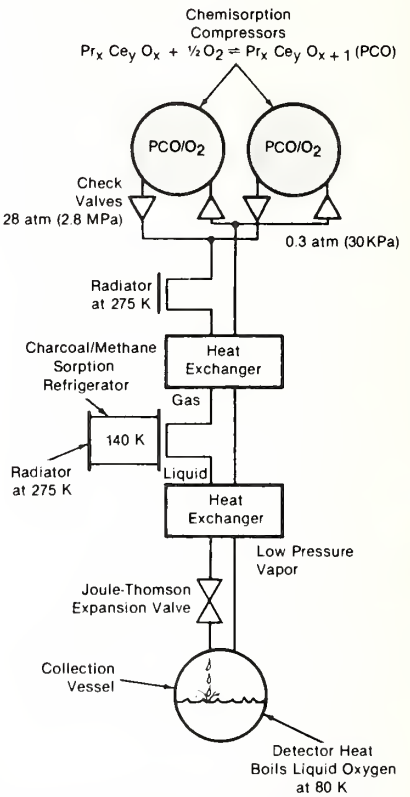

In the **Chemisorption Refrigerator,** PCO alternately absorbs and desorbs oxygen, depending on whether it is cooled or heated. One of a pair of compressors accepts oxygen while the other releases it. The compressed oxygen is liquefied when precooked and expanded.

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NASA Tech Brief
National Aeronautics and Space Administration

Licensing Opportunity

Extinguishing Fuel-Leak Fires in Jet Engines

Potassium dawsonite and several other chemicals are effective in delaying reignition.

A report describes tests of dry chemicals for extinguishing fires on jet engines. Research in this field continues because fires from in-flight fuel leaks grow more difficult to extinguish as airspeeds, engine case temperatures, and bleed-air temperatures increase. The current practice for extinguishing such fires is to spray the flames with a Halon, such as CF_3Br, CF_2Br_2, or CF_2ClBr. However, more effective extinguishants are still being sought.

In static tests, jet fuel was fed in drops by gravity through a 0.1-centimeter-diameter tube into a trough heated to a temperature between 700 and 900 °C by an underlying electric heater. A thermocouple welded to the trough measured the temperature near where the drop fell.

When the fuel burst into flames, a given weight of dry extinguishant was discharged into the trough near the impinging drops. The dry chemical usually extinguished the fire, but the fuel drops were allowed to continue to fall into the trough and eventually were reignited by the heated trough. The time from the first extinguishment to the second fire — the so-called reignition delay time — was the prime measurement in ranking the effectiveness of the dry-chemical extinguishants.

In dynamic tests, jet fuel was dropped on an electrically heated stainless-steel cylinder, while air flowed over the surface at speeds ranging from 6 to 36 meters per second. After ignition, a given weight of extinguishant was discharged onto the surface, and the reignition delay time was measured.

The report concludes that certain dry chemicals have greater effectiveness per unit weight than do Halons in controlling fuel-leak fires, particularly at high airflow rates. For example, K_2CO_3, $KHCO_3$, and $KC_2N_2H_3O_3$ ("monnex") are better than CF_2ClBr in delaying the hot-surface reignition of these fuel-leak fires after initial extinguishment. One of the promising new extinguishants is a mixture of potassium dawsonite $[KAl(OH)_2CO_3]$ with KCl or KI. When discharged on a jet fuel fire, this dry powder sticks to hot surfaces. After it puts out the fire, its residue acts as a barrier that delays reignition, even when fuel continues to leak on the surfaces. All conclusions remain tentative, however, and flight tests will be needed to prove the effectiveness of dry extinguishants in nacelle fires.

This work was done by R. L. Altman of **Ames Research Center**. *To obtain a copy of the report, "Extinguishing Fuel-Leak Fires With Dry Chemicals,"*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center Refer to ARC-11553./TN

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NASA Tech Brief
National Aeronautics and Space Administration

Overview of Fiber-Optical Sensors

The design, development, and sensitivity of sensors using fiber optics are reviewed.

The state-of-the-art and probable future developments of sensors using fiber optics are described in a 14-page report that includes 35 references to work in the field. The report serves to update previously published surveys. Systems incorporating fiber-optic sensors are used in medical diagnosis, navigation, robotics, sonar, the power industry, and industrial controls.

The report summarizes the operating principles, advantages, and disadvantages of Mach-Zehnder, Michelson, Sagnac, and ring-resonator fiber-optic interferometers, which can be used to form sensors. The two common methods for introducing a transducer into the sensor arm of a Mach-Zender interferometer are discussed: (1) wrapping the fiber around a mandrel that is sensitized to whatever is to be monitored and (2) applying a sensitized coating to the optical fiber. Mandrels and coatings suitable for acoustic, electric, magnetic, and thermal measurements are described. Equations describing the phase-modulation process for coated fibers are also presented.

The report describes two types of rotation sensors (both based on the Sagnac interferometer) that can be used in lieu of mechanical gyroscopes. The lowest reported drifts achieved thus far are 0.005 degree/(hour)$^{1/2}$ for an all-fiber gyroscope and 0.025 degree/(hour)$^{1/2}$ for a hybrid fiber-optic gyroscope.

Ten fiber-optical methods for sensing temperature are listed. The performances of acoustic, magnetic, electric, rotation, and temperature sensors are compared. The authors note the considerable difficulties in eliminating both unwanted sensitivity to temperature in fiber-optic sensors intended to monitor parameters other than temperature and sensitivity to other parameters in devices meant to sense temperature alone.

Existing and potential applications of fiber-optic sensors in medicine and robotics are outlined. The report concludes with an overview of the state of development and unsolved problems for various components (couplers, fibers, integrated optics, modulators, polarizers, and light-source diodes) used in fiber-optic systems.

This work was done by Ramon P. DePaula and Emery L. Moore of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Fiber Optic Sensor Overview," NPO-16817 /TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE

Environmental Science & Technology

1184 Dewater of Dilute Aqueous Hazardous Wastes Using Reversible Gel Absorption

1185 Destruction of Dioxin-Contaminated Solids and Liquids by Mobile Incineration

1186 Survival and Transport of Pathogens in Sludge-Amended Soil — A Critical Literature Review

Other items of Interest

1321 Physical Response of Flat Steel Plates to Drop-Hammer Impacts

United States
Environmental Protection
Agency

Hazardous Waste Engineering
Research Laboratory
Cincinnati OH 45268

Research and Development

EPA

Project Summary

Dewater of Dilute Aqueous Hazardous Wastes Using Reversible Gel Absorption

The feasibility of using crosslinked gels in a reversible process for extracting pure water from aqueous waste solutions has been investigated. It has potential for conentrating waste streams that contain hazardous chemicals. Near critical gels have been developed that swell and collapse as a function of process conditions. At low temperature or high pH, these gels swell by absorbing water. During swelling, they exclude larger solutes, including many hazardous materials. Solutes and colloidal pollutants thus may be concentrated to facilitate treatment and disposal. The gels are made from water soluble monomers; they can be easily regenerated by warming or by adding acid to release the purified water. The collapsed gels are separated by filtration and reused.

In this study gels have been contacted with solution containing a wide range of different molecular weight solutes and colloids to determine water extraction capacity and efficiency of solute rejection.

Introduction

Recently published studies have reported the use of water soluble gels to achieve essentially the same type of separation that can be obtained with membrane processes. The physical-chemical concepts that underlie gel extraction are related to the separation mechanisms encountered in molecular size ultrafiltration membrane separations, e.g., size exclusion, and ion selective membrane separations, e.g., ion exclusion. However, operational problems that stem from the need for high pressure and concentration polarization are overcome in gel separation because of the large surface area of the gels. Furthermore, the previous research on gels indicated that a reversible gel absorption process could be developed. This would allow reusing gels in a continuous process that meets the operating criteria listed above. Research on the development and use of gels was therefore undertaken.

This reserach had two objectives; the first was to develop near critical water soluble polymer gels which would swell and collapse in aqueous solutions with minor changes of temperature or pH; the second was to evaluate the effectiveness of these gels for concentrating dilute solutions of hazardous wastes.

The gels were made of substituted crosslinked acrylamides. One of the more successful temperature-sensitive gels is a polyisopropylacrylamide that was made by polymerization of N-isopropylacrylamide. pH-sensitive gels were made by polymerization and subsequent hydrolysis of acrylamide or by co-polymerization of acrylamide and sodium acrylate. With these two gels in hand, laboratory tests were set up to define mechanisms by which the gels worked, how much water they can imbibe and release, and what types of solute molecules and colloids would be rejected from entering the gel phase.

The theoretical background that explains the behavior of gels relates to behavior of solutions near a phase transition. Phase transitions are illustrated in Figure 1. In the upper left-hand corner of this figure, the phase diagram for a regular solution is shown as a plot of temperature *vs.* solute mole fraction x_2. The phase diagram is shaped like a parabola. Above this parabola, the system is a single phase; under the parabola, it is two phases whose compositions are exemplified by the ends of the horizontal dashed line. When a system of known concentration is cooled, it can initially be one phase and later become two phases, as suggested by the vertical dashed line.

The phase distribution of a regular solution as shown by the parabolic domains is a special case of solution behavior. The more general case is illustrated in the upper right-hand corner of Figure 1; it is the phase diagram for water-triethylamine. As before, the phase diagram consists of a plot of temperature *vs.* composition, which is expressed as a volume fraction ϕ_2. Like a regular solution, this system forms one phase at very high temperatures. Unlike regular solutions it also forms one phase at low temperatures; in between, it forms two phases. When a solution of water-triethylamine containing one phase is cooled, it again follows a locus

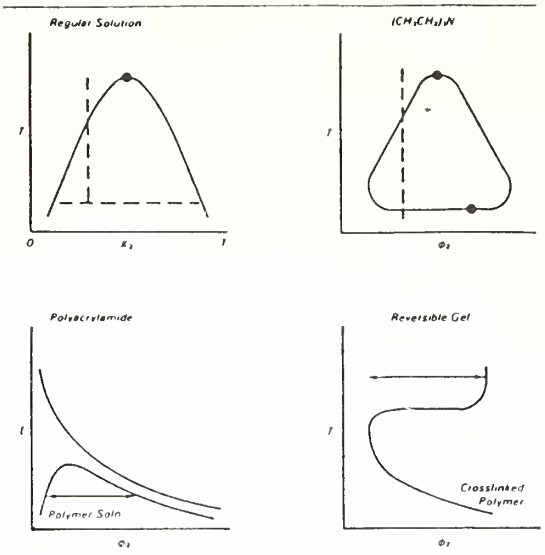

Figure 1 Phase diagrams
T temperature ϕ_2 volume fraction

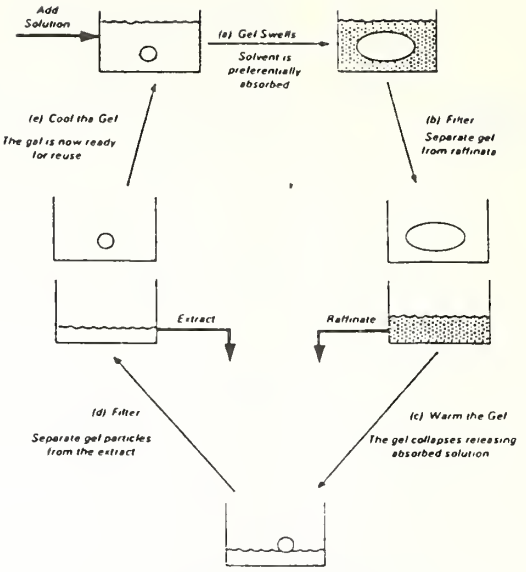

Figure 2. A separation process based on temperature sensitive gels

like the vertical dashed line. At high temperature it initially contains one phase. As it is cooled, it forms two phases. As it is cooled further, it forms one phase again. The behavior of a regular solution and of water-triethylamine is often discussed in terms of critical points, or, as they are more commonly called in liquid solution, consolute points. These consolute points are shown as the heavy black dots in Figure 1. A regular solution forms only one consulate point, called an upper consolute point.

These same concepts have been extended to describe the behavior of water soluble polymers. For uncrosslinked polyacrylamides, the phase diagram is shown in the lower left-hand corner of Figure 1. This phase diagram agains plots temperature *vs.* composition expressed as volume fraction ϕ_2. The phase diagram for the uncrosslinked polyacrylamide, shown by the lower of the two curves, looks like a regular solution, which has been bent strongly to the left. This bending is a consequence of the polymeric chains, which imply a solute of dramatically different molecular weight than the solvent.

However, if the polyacrylamide is crosslinked like our gels then the phase diagram is like the upper curve. At low temperature, the upper curve is similar to the lower curve for an uncrosslinked polymer. However when ϕ_2 is small, that is, when the polymer is dilute, the uncrosslinked polymer dissolves completely in the solvent. The crosslinked polymer swells to a maximum value. As a result a crosslinked polyacrylamide never fully dissolves, and its phase diagram shoots upwards.

The polymers used in this study can be represented by the superposition of the phase diagram for the crosslinked polyacrylamide and the phase diagram for triethylamine-water. At low temperatures, the phase diagram is like that shown in the lower left-hand corner, but at high temperatures the phase diagram follows the schematic shown in the upper right-hand corner. Overall behavior is characterized by a phase diagram like that shown in the lower right-hand corner of Figure 1.

Gels that have a phase diagram like that in the lower right-hand corner of Figure 1, would be expected to show temperature related volume changes as described in the experimental results of this report. In particular, when the gel is warmed, ϕ_2 will get slightly smaller and the gel volume will get slightly bigger. However, at a critical higher temperature, ϕ_2 will get much bigger and the gel volume will get much smaller. In many cases, this volume change with temperature can be abrupt. For example, the crosslinked polyisopropylacrylamide polymer described in this report showed a 5-fold volume change over a temperature increase of only 0.1°C.

These models were used as a theoretical framework for analyzing and correlating data on volume changes of the gels. The models also gave insight on development of new gels and the physical configuration of the gels.

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***Mark J. Stutsman** is the EPA Project Officer (see below)*
The complete report, entitled "Dewatering of Dilute Aqueous Hazardous Wastes Using Reversible Gel Absorption," (Order No. PB 87-168 761/AS; Cost: A05, subject to change) will be available only from:
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The EPA Project Officer can be contacted at:
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United States
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Research and Development

EPA

Project Summary

Destruction of Dioxin-Contaminated Solids and Liquids by Mobile Incineration

The EPA Mobile Incineration System, which consists of a kiln, secondary combustion chamber, air pollution control unit, and separate continuous stack gas analysis capabilities, was rigorously tested in 1982-1983 using PCB-contaminated liquids and other chlorinated organic fluids. Destruction and removal efficiencies of at least 99.9999% were consistently attained at a heat release of 10 GJ/hr.

As a result of these favorable performance data, a project was initiated to evaluate the technical, economic, and administrative feasibility of on-site incineration of dioxin-contaminated materials. During 1984, the system was extensively modified for field use and performance-tested with a variety of uncontaminated soils and other solid wastes at the EPA facility in Edison, NJ.

Based on the results of laboratory and pilot plant studies conducted to establish optimum kiln conditions and the available literature, the EPA system was judged to be more than adequate for detoxifying dioxin-contaminated solids and liquids, and thus could be expected to accomplish a successful dioxin trial burn. Accordingly the system was transported in December 1984 to the Denney Farm site in McDowell, Missouri, which had been selected for the trial burn in the intervening months.

Destruction and removal efficiencies exceeding 99.9999% were achieved for 2,3,7,8-TCDD during a trial burn on dioxin-contaminated liquids and solids conducted in April 1985. The kiln ash and process wastewater by-products had no detectable dioxins and were in accordance with guidelines identified by EPA's Office of Solid Waste.

A field demonstration on a variety of dioxin-contaminated materials was conducted between July 1985 and February 1986. A total of 0.9 million kg of solids and 81,600 kg of liquids was successfully decontaminated during that time. Operations were suspended on February 6, 1986 pending Superfund reauthorization. When operations resume, the Field Demonstration will be completed and a second trial burn will take place on materials designated by the Resource Conservation and Recovery Act and the Toxic Substances Control Act.

Introduction

The continued discovery of abandoned hazardous waste sites by Superfund investigations, decreasing availability of landfill sites, and increasing public opposition to toxic and hazardous waste transport have placed increasing pressure on the U.S. Environmental Protection Agency (EPA) to find alternatives for treating and disposing of toxic and hazardous wastes. The treatment and disposal problem is particularly acute in the case of the highly toxic dioxin isomer 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD). In recognition of these difficulties and as a result of preliminary favorable tests of the technology, EPA's "Dioxin Strategy" (November 28, 1983) recommended that high-temperature incineration of dioxin-contaminated materials be evaluated further by the Office of Research and Development (ORD).

The EPA Mobile Incineration System (MIS) was designed and constructed for ORD to provide such treatment at the actual site of dioxin contamination. The system consists of a refractory-lined rotary kiln, a secondary combustion chamber (SCC), and air pollution control equipment mounted on three heavy-duty semi-trailers. Monitoring equipment is carried by a fourth trailer. The ability of the MIS to destroy tetrachloromethane (carbon tetrachloride), dichlorobenzene, trichlorobenzenes, tetrachlorobenzenes, and PCBs while complying with applicable Federal and State regulations for the emissions of HCl and particulate matter was demonstrated during a Liquid Trial Burn conducted between September 1982 and January 1983 at the EPA facility in Edison, NJ.

In March 1984, the ORD Releases

Control Branch (RCB) of the Hazardous Waste Engineering Research Laboratory (HWERL), at the request of the EPA Region VII, embarked on a field validation project to evaluate the MIS for on-site treatment and disposal of toxic and hazardous wastes, particularly soils contaminated with 2,3,7,8-TCDD. The purpose of this research was to determine the economic feasibility of the technique and to establish: (1) test burn protocols; (2) health and safety protocol; (3) site specific, risk assessment protocol, (4) an economic model for estimating the cost of treatment per unit of material processes; and (5) national and state permit protocol.

Recommendations

The following recommendations are the result of the experience gained during the design, operation, and maintenance of the MIS Trial Burn and Field Demonstration in Missouri. The recommendations center around the need to prepare for the following circumstances:

- extreme weather conditions
- mechanical failures
- road bed failure due to inadequate site preparation
- unavailability of spare parts

In addition, it is recommended that the permitting process be started as soon as the site is chosen. The delisting protocol required analytical tests on every tank of wastewater and on relatively small quantities of treated soil to confirm that the extracts of the material met RCRA Extraction Procedure (EP) toxicity criteria before discharge or disposal. In retrospect, securing a National Pollution Discharge Elimination System (NPDES) permit may have allowed more efficient site preparations and decreased analytical costs (due to longer analytical turnaround time) since NPDES permits normally require less frequent sampling and reporting of analytical results.

H. Mortensen and A. Sherman are with Enviresponse, Inc., Livingston, NJ 07039. W. Troxler, R. Miller, and C. Pfrommer are with IT Corp., Knoxville TN 37923

***Frank Freestone** is the EPA Project Officer (see below)*

The complete report, entitled "Destruction of Dioxin-Contaminated Solids and Liquids by Mobile Incineration," (Order No. PB 87-188 512/AS; Cost: $18.95 subject to change) will be available only from

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Releases Control Branch
Hazardous Waste Engineering Research Laboratory—Cincinnati
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United States
Environmental Protection
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Research and Development

EPA

Project Summary

Survival and Transport of Pathogens in Sludge-Amended Soil

A Critical Literature Review

A study was undertaken to critically review available information on the survival and transport of pathogens from municipal wastewater sludges applied to land. Unfortunately, the amount of quantitative, comparable data related to pathogen behavior in sludge-amended soils is extremely limited. Most available data are restricted to *Salmonella* and indicator bacteria.

In general, *Salmonella* showed a 90% (T_{90}) reduction within 3 weeks in sludge-amended soils. In warm climates, inactivation of viruses near the surface was quite rapid, with a median T_{90} of 3 days. However, at low temperatures, T_{90} values of approximately 30 days were observed for viruses. Maximal parasite survival, as determined by *Ascaris* ova recovery, was relatively long near the surface, with a median T_{90} of 77 days.

Extremely limited vertical movement of some pathogens may be anticipated in sludge-amended soils. Although monitoring at sludge application sites has not revealed that sludge amendment affects the bacterial quality of groundwater, limited transport of indicator bacteria to depths up to 180 cm has been reported. Under field conditions including exposure to natural rainfall, virtually no viruses have been detected in soil-water percolates. Available literature strongly favors the contention that parasitic ova are retained at the point sludge is introduced to the soil. Finally, insufficient data are available for adequate modeling of pathogen survival and transport in sludge-amended soils.

Conclusions

1. The number of quantitative, comparable data describing pathogen survival or transport in sludge-amended soils are extremely small. Survival data are available only for *Salmonella* sp., selected enteric viruses, and *Ascaris* ova, and studies on pathogen transport are limited to *Yersinia* sp. and certain viruses.
2. Where adequate quantitative data exist, these observations can be made:
   - Inactivation of indicator bacteria as described by median T_{90} values was greater than that observed for *Salmonella*.
   - Viral inactivation appears to be faster than *Salmonella* inactivation near the soil surface. However, all but one study used to estimate viral die-off were conducted in rather narrow temperature ranges, thus highlighting a potential bias in the application of these values.
   - Inactivation of parasites near the soil surface is relatively slow, perhaps as much as 5 times slower than *Salmonella* inactivation and more than 13 times slower than virus inactivation.
3. Exceedingly long survival times somtimes cited for *Salmonella* arise from studies in which high levels of added organisms (10^6 - 10^{10}/L) were present.
4. The only strong evidence for bacterial regrowth in sludge-amended soils is related to organisms of the coliform indicator group.
5. Of the physical and meteorological parameters considered, only temperature could be correlated with microorganism survival.
6. Inadequate data exist to assess critically the vertical transport of pathogens from sludge-amended soils. However, several general observations can be made:
   - Data collected at all but one operational field site have not demonstrated a deterioration of groundwater quality related to sludge application.
   - Selected studies have documented limited bacterial movement to depths of 180 cm beneath sludge-amended soil.
   - Limited laboratory studies suggest that viral retention is enhanced in sludge-amended soils compared with effluent-irrigated soils.

- The size of parasites appears to preclude their vertical movement from sludge-amended soils, but studies designed to address this question were not found.

7. Exceedingly few studies have addressed the issue of microorganisms in runoff from sludge-amended soils. However, there is a high probability that uncontrolled runoff wil contain pathogens as long as viable organisms are present in sludge-amended soils.
8. Insufficient data are available for adequate modelling of pathogen survival or transport in sludge-amended soils. Not only are microbial results limited, but prevailing environmental and soil conditions have not been adequately documented in many published reports.

Recommendations

The following specific recommendations are designed to obtain the data required to formulate a more complete understanding of the survival and/or transport of pathogens in sludge-amended soils:

1. Studies specifically designed to develop such comprehensive data should be conducted.
2. These studies should be restricted to representative pathogens such as *Salmonella*, selected human enteric viruses, and parasites indigenous to municipal wastewater sludges.
3. Though it would be desirable to conduct such studies under field conditions with indigenous organisms, this approach may be limited by the levels of pathogens in sludges coupled with the relative insensitivity of currently used detection methods and the existence of a wide variety of uncontrolled environmental variables.
4. The use of selected seeded organisms in sludges under closely controlled laboratory conditions may be the most reasonable approach.
5. Laboratory experimentation must be carefully designed to simulate a range of temperature, moisture, sludge loading conditions, and soil types found nationwide.

The full report was submitted in fulfillment of Cooperative Agreement No. CR811918-01-0 by The University of Texas under the sponsorship of the U.S. Environmental Protection Agency.

Charles A. Sorber and Barbara E. Moore are with the University of Texas at Austin, Austin, TX 78712
***Albert D. Venosa** is the EPA Project Officer (see below).*
The complete report entitled "Survival and Transport of Pathogens in Sludge Amended Soil: A Critical Literature Review," (Order No. PB 87-180 337/AS; Cost: $18.95, subject to change) will be available only from:
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Water Engineering Research Laboratory
U.S. Environmental Protection Agency
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Organisms of Major Concern in Land Application of Municipal Wastewater and Sludges

Group	Name of Organism	Primary Disease	Remarks
Bacteria	Legionella pneumophila	Acute respiratory disease	Aerosol transmission documented, but no cases linked to wastewater exposure to date
	Salmonella sp	Gastroenteritis, typhoid and paratyphoid fever	
	Shigella sp	Bacillary dysentery	Overt pathogens but low probability of occurrence in wastewater in the United States
	Vibrio cholerae	Cholera	
Viruses	Hepatitis A virus	Infectious hepatitis	Documented waterborne transmission
	Non-A, Non-B hepatitis	Hepatitis	Preliminary evidence for waterborne transmission
	Norwalk-like agents	Gastroenteritis	Documented waterborne transmission
	Rotavirus	Gastroenteritis	Documented waterborne transmission
Helminths	Ascaris sp	Ascariasis	
Protozoans	Giardia lamblia	Giardiasis (Gastroenteritis)	Documented waterborne transmission

Manufacturing, Machinery, & Tools

1187 Process Planning System to Serve as Industry Model

1188 Stress Wave Riveting

1189 Acoustic Levitation With One Transducer — Higher resonator modes enable the simplification of equipment.

1190 Adapting a Robot Hand to Specialized Functions — A special-purpose end effector is quickly joined to a general-purpose gripper. (Licensing Opportunity)

1191 Electrochemical Machining Removes Deep Obstructions — An inexpensive technique can salvage expensive parts.

1192 Fault Detection and Isolation for Hydraulic Control — Pressure sensors and isolation valves act to shut down a defective servochannel.

1193 Impact Driver With Integral Sliding Hammer — Accidental injury and damage are less likely.

1194 Removing Silicon Monoxide From Nickel Mirrors — Adherent fragments are detached by gentle polishing.

1195 Solenoid Valve With Self-Compensation — Paired upstream and downstream seals balance sealing forces. (Licensing Opportunity)

Software

1196 Assembly-Line Simulation Program — Costs and profits are estimated for models based on user inputs.

Testing & Instrumentation

1197 Process Sensor Developed to Measure Internal Temperatures in Extruded Aluminum

Other items of Interest

1355 Pickling of Stainless Steels

Process Planning System to Serve as Industry Model

Work on process planning done at the AMRF is serving as a model for a new planning system under development at Texas Instruments' (TI) Defense Systems and Electronics Group.

Researchers from academia, government, and private industry, including Research Associates from TI, worked cooperatively on the three-year effort that produced the AMRF system. They combined real-world problems and experience with advanced artificial intelligence techniques from academia to achieve unique solutions to process planning problems. Texas Instruments RAs provided shop floor knowledge used to drive an expert process selection module of the planning system. Dr. Dana Nau of the University of Maryland provided a frame-based hierarchical reasoning system.

Because it is designed around an interactive framework, the AMRF process planning system supports all control systems on the shop floor. The first expert planning module integrated into this framework was the expert process selection module which uses a feature-based description of a part as input. The features come from the AMRF part model which contains all of the information normally found on a part drawing.

The AMRF process planning system starts with a machinable feature, such as a pocket, slot or groove, and determines the lowest cost machining process or sequence of processes required to produce that feature. The system uses the same approach for each process to select appropriate tooling, and to calculate speeds and feeds, and other processing parameters. Other expert systems are being developed to address machine selection and resource utilization.

This process planning project is an example of how knowledge and experience can be combined in the environment of the AMRF to meet the needs of American industry.

For Additional Information:

To discuss the VWS2 effort further, contact:

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Stress Wave Riveting

A study which explored the use of stress wave riveting techniques in aircraft assembly and repair operations has recently been completed. "Stress Wave Riveting (SWR) for Assembly and Repair for Navy Aircraft" was sponsored by the Naval Air Systems Command under MT project number A1325, and was conducted at Grumman Aerospace Corporation.

The major objective of this project was to demonstrate the feasibility of utilizing the SWR process in a cost-effective production operation for aluminum assemblies. The SWR technique harnesses stress waves produced by a SWR gun. The gun is powered by high voltage. When the stress waves are applied to hardened pins, this process has the unique effect of driving those pins into holes of large interference. This results in interference fits that improve fatigue life and provide fuel-tight sealing. Test results show that SWR can accommodate holes of lesser precision or quality and produce a residual stress field of superior crack initiation and growth inhibiting characteristics.

A detailed final report for this project has been completed and is available upon request. For a copy of the final report or for more information concerning the project, please contact:

Commander,
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AV 624-2173

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Acoustic Levitation With One Transducer

Higher resonator modes enable the simplification of equipment.

An experimental acoustic levitator for high-temperature containerless processing has a round cylindrical levitation chamber and only one acoustic transducer. Stable levitation of a solid particle or liquid drop is achieved by exciting the sound in the chamber to a higher-order (nonplanar) resonant mode that makes a potential well for the levitated particle or drop at some point within the chamber.

Previous levitation schemes have involved different types of chambers and transducers. In the triple-axis resonant method, a sample is levitated in the potential well formed by the superposition of three orthogonal plane standing waves from three transducers in a rectangular chamber. In the single-axis interference method, a sample is levitated in the potential well formed near an acoustic reflector by the interference between the reflected waves and the waves incident upon the reflector from a single transducer. The new method is related to the single-axis interference method but takes advantage of reflections from all the walls of an enclosed chamber.

Theoretical studies of acoustic-resonance-positioning theory have been conducted to aid the design of single-mode levitators, with attention to such matters as the following:

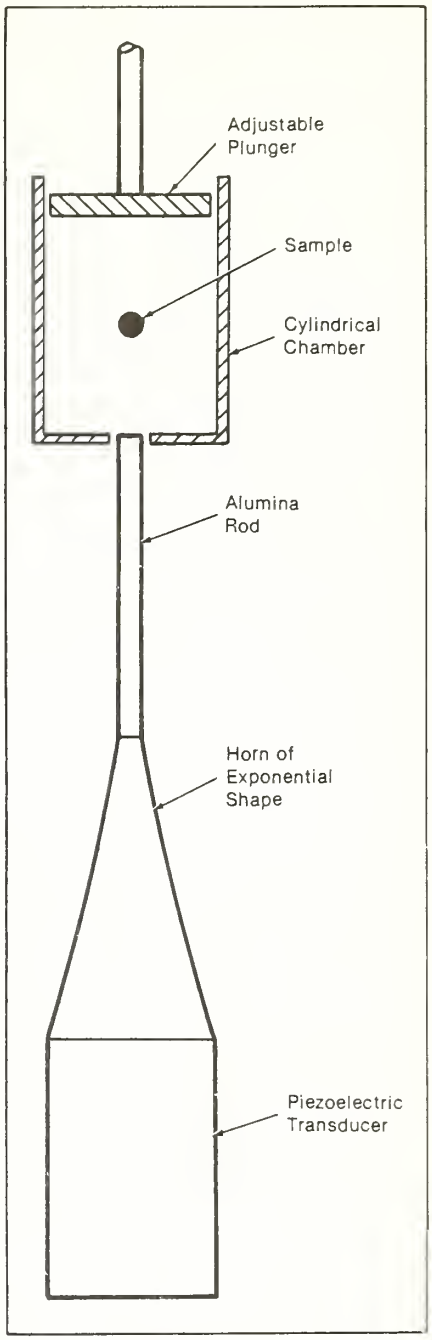
- The magnitudes of the acoustic restoring forces;
- The optimum chamber dimensions to maximize the restoring forces; and
- The temperature dependence of the restoring forces.

The translational and rotational stability of the sample would also normally be a matter of concern in such studies. However, in a single-mode levitator, the inherent phase coherence of the orthogonal force components automatically assures stability, and controlled sample rotation can be introduced by the excitation of more than one mode.

In the experimental single-mode levitator (see figure) a 20-kHz piezoelectric transducer is coupled to the high-temperature levitation chamber by a solid horn and an alumina rod. The speed of sound in this solid transmission medium varies only slightly with temperature, and the density is nearly constant; consequently, a relatively high degree of acoustic-energy transfer is maintained over a wide temperature range. The alumina rod withstands high temperatures and acts as an acoustic waveguide between the horn and the chamber.

For stable levitation at 1,500 °C in argon, calculations indicate an optimum chamber length of 3.8 cm and a radius of 2.9 cm, using the zero-order azimuthal, first-order radial, first-order axial mode. Other resonance modes could also be chosen. The correct chamber length for the excitation of a particular resonance mode is obtained by adjusting the plunger.

This work was done by Martin B. Barmatz of Caltech for **NASA's Jet Propulsion Laboratory**. *NPO-16867 /TN*



The **Single-Mode Acoustic Levitator** requires only one transducer. A nonplanar acoustic-resonance mode provides translationally and rotationally stable levitation of the sample.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
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NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Licensing Opportunity

Adapting a Robot Hand to Specialized Functions

A special-purpose end effector is quickly joined to a general-purpose gripper.

An adaptor enables mechanical and electrical connections to be made easily between a special-purpose end effector (robot hand) and the arm of a robot or remote manipulator. Use in prosthetic devices is also contemplated. With the adaptor, the hand can be changed quickly from a device designed to grasp objects of various sizes and shapes to a device intended to do a specific task efficiently. Examples of such special-purpose end effectors are a drill and a set of jaws for gripping only one kind of object; for example, an electromagnetic hammer or a camera.

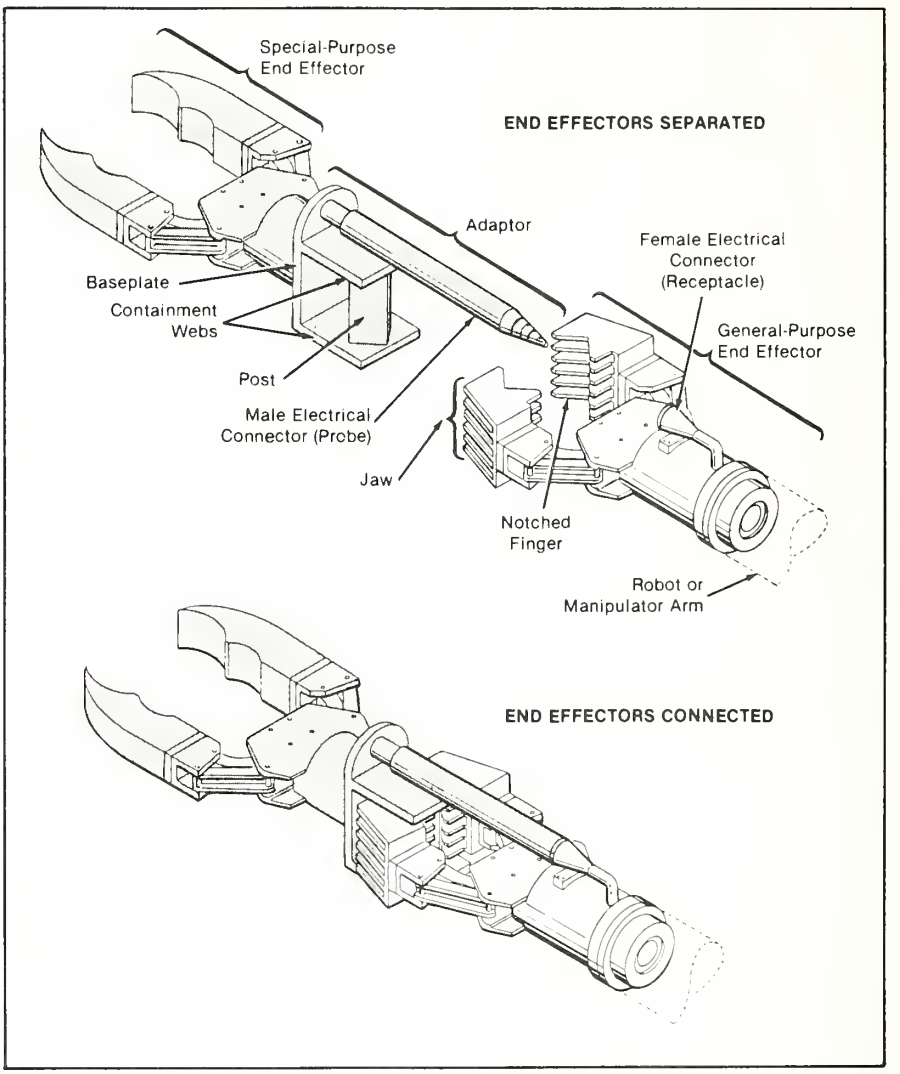
The general-purpose end effector is a pivoted pair of jaws with notched, interleaving fingers (see figure). The adaptor consists of an end plate, containment webs, a post, and an electrical probe. The special-purpose effector is mounted on the adaptor.

The adaptor is placed on the general-purpose end effector such that the jaws close on the adaptor post, gripping it securely; the notched fingers on the jaws prevent the post from twisting or rotating. Because the containment webs prevent the jaws from sliding vertically on the post, the adaptor is rigidly joined to the general-purpose effector.

The conical tip of the electrical probe aligns itself with the electrical receptacle on the general-purpose effector. Contacts on the probe mate with contacts in the receptacle and carry electrical signals from a controller to and from the special-purpose end effector.

This work was done by Keith H. Clark of **Marshall Space Flight Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center Refer to MFS-25949/TN



The **Special-Purpose End Effector** is connected to the general-purpose end effector through an adaptor, forming a rigid unit. The special-purpose effector can be any of a variety of types; the one shown here picks up bundles of tubes.

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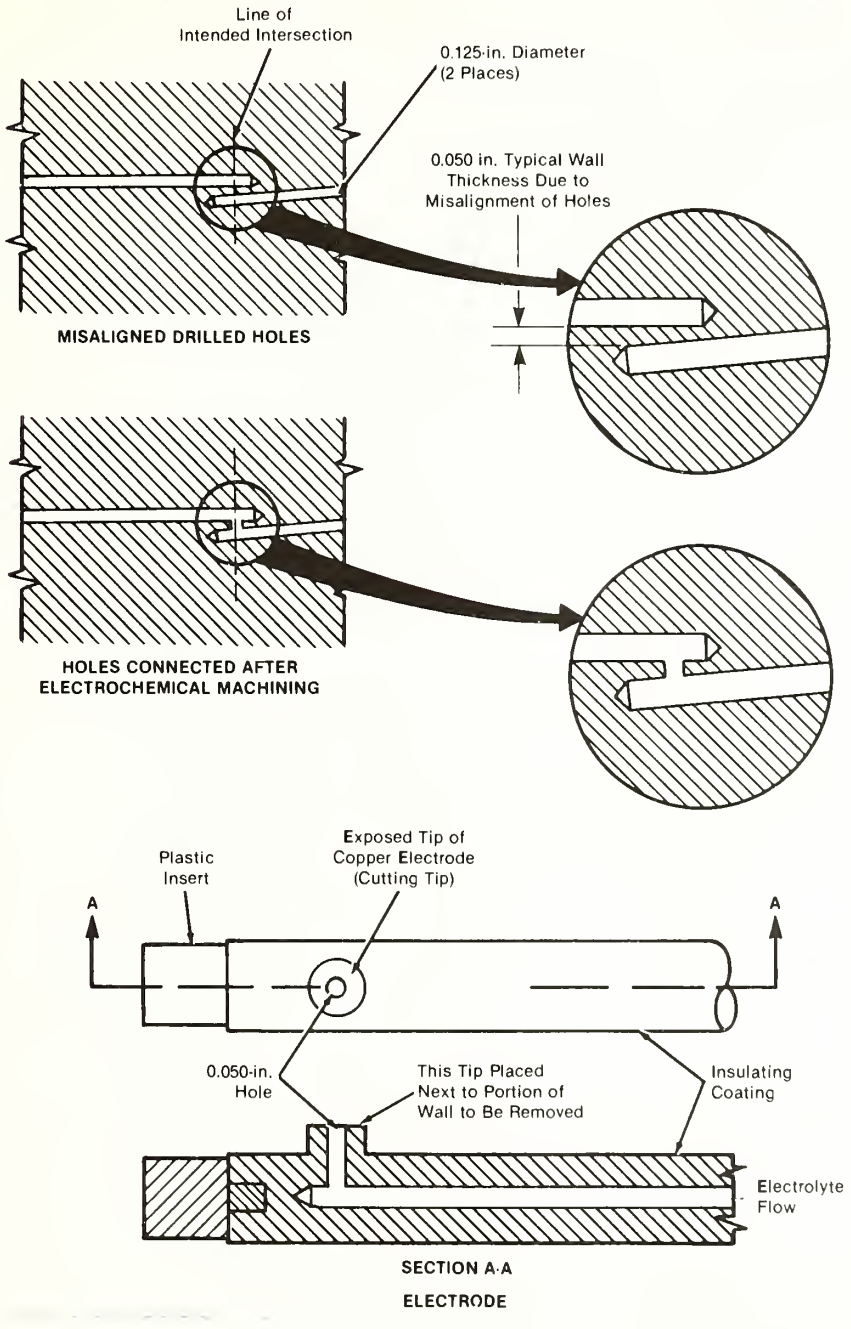
REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Electrochemical Machining Removes Deep Obstructions

An inexpensive technique can salvage expensive parts.



Electrochemical machining (ECM) is an effective way of removing obstructing material between two deep holes that are supposed to intersect but do not because of misalignment of the drilling tools. ECM makes it possible to rework costly castings that would otherwise have to be scrapped.

ECM produces smooth surfaces and transition radii. It does not cause metallurgical damage and makes postprocessing treatments unnecessary. It is highly cost-effective because of its simple tooling, short setup time, and cutting speed.

An electrode is inserted in one of the holes with its tip near the obstruction (see figure). An electrolyte solution flows through the core of the copper electrode and out through a hole near the exposed tip while direct current passes between the workpiece (connected as the anode) and the tip of the electrode (the cathode in the electrochemical circuit). The action of the current and the electrolyte removes metal from the workpiece. Since the obstructing wall is thin [typically about 0.05 in. (1.3 mm)], it is quickly dissolved. The method is fast even for tough or hard alloys and complicated three-dimensional shapes.

This work was done by Mark J. Catania of Rockwell International Corp. for **Marshall Space Flight Center**. *No further documentation is available.*
MFS-29118/TN

Coolant Channels Drilled in a Metal Block failed to intersect because of the difficulty of aligning drill bits accurately in the long holes. The electrochemical-machining electrode can be inserted in either hole to remove the obstructing wall between the channels.

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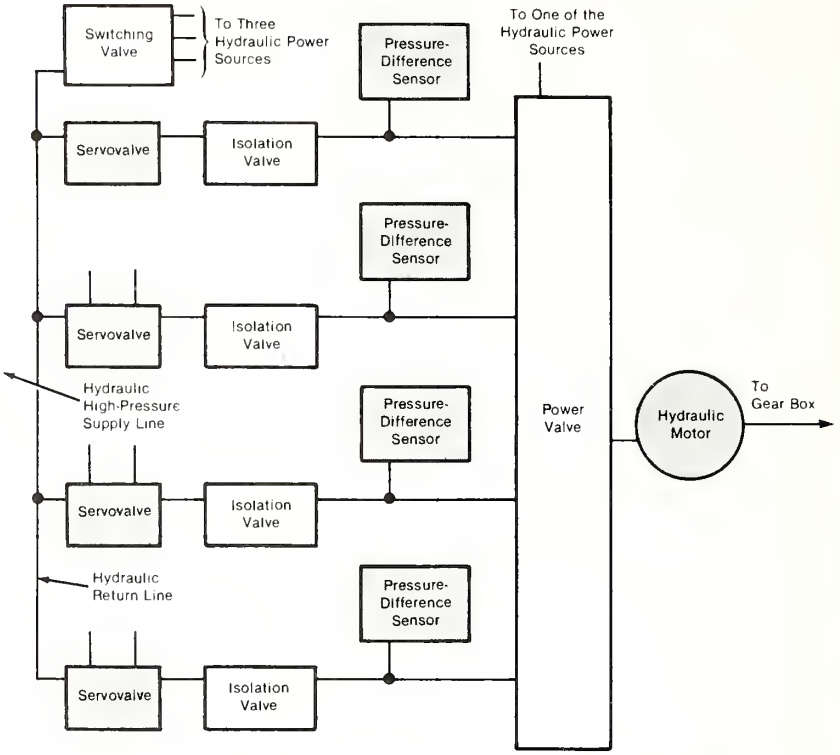
NASA Tech Brief
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Fault Detection and Isolation for Hydraulic Control

Pressure sensors and isolation valves act to shut down a defective servochannel.



Any Combination of Two servovalves will operate the power valve. While a channel is failing and its servovalve differential pressure is rising, the good channels will fight against its spurious commands. When the overpressure in the failed channel stabilizes, the sensor and isolation valve cut it off from the rest of the system.

A redundant hydraulic system indirectly senses a failure in any of its electrical control channels and mechanically isolates the hydraulic channel controlled by the faulty electrical channel so that it cannot participate in operating the system. With the failure-detection and -isolation technique, the system can sustain two failed channels and still function at full performance levels.

The technique was developed for two similar hydraulic systems on the Space Shuttle: one for the rudder and one for the speed brake. In both systems, command signals are sent to a power drive unit, which sets the positions of aerodynamic control panels. The scheme may be useful on aircraft or other systems with hydraulic servovalves where failure cannot be tolerated.

In either system, four servovalves feed each power valve, which sums their hydraulic control signals (see figure). The power valve in turn controls a hydraulic motor that drives the rudder or speed brake through a gearbox. The power valve and motor are triply redundant. A switching valve selects one of three hydraulic power sources to supply power to the servovalves.

One of the peculiarities of these systems is that if an electric control channel fails, the servovalve output pressure will be high on one leg — about 3 times as high as normal. A differential-pressure sensor continuously monitors the output pressure of each servovalve. When a sensor detects this large pressure difference, it activates an isolation valve on the servovalve output, and the channel is removed from service.

If another electrical channel should fail, the pressure difference in the output of the affected servovalve will again rise — this time to twice the normal value. Again the sensor will detect the high differential pressure and activate the associated isolation valve. Even with two channels out of service, the power drive unit will be able to operate the rudder and speed brake normally.

This work was done by Sundstrand Energy Systems for **Johnson Space Center**. *MSC-20760/TN*

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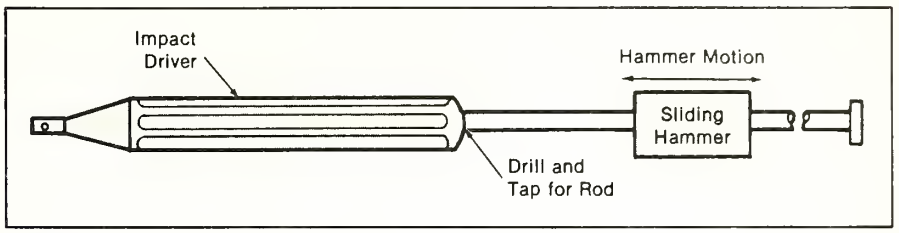
NASA Tech Brief
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Impact Driver With Integral Sliding Hammer

Accidental injury and damage are less likely.

A tool combines an impact driver with a sliding dead-blow hammer. It can be used for any purpose for which an ordinary impact driver would be used — tightening fasteners or driving starter holes for a drill, for example. At the same time, the tool protects the user from accidental injury and the surrounding equipment from damage that might occur from an ordinary arm-wielded hammer. It promises to be especially useful in underwater work, where the viscous nature of the medium makes accurate free hammering difficult.

The tool is an off-the-shelf impact driver that has been modified by the addition of a rod and sliding hammer (see figure). The user merely slides the cylindrical hammer back and forth on the rod, thereby subjecting the head of the driver to repeated blows. A disk at the outer tip of the rod prevents the hammer from disengaging.



The **Hammer Slides on a Rod**, making it impossible for the user to miss hitting the impact driver squarely on the head. The rod is 12 to 18 inches (30 to 46 centimeters) long.

This work was done by Bilby J. Wallace of OAO Co. for **Johnson Space Center**. *No further documentation is available. MSC-20582 /TN*

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NASA Tech Brief
National Aeronautics and Space Administration
Goddard Space Flight Center, Greenbelt, Maryland

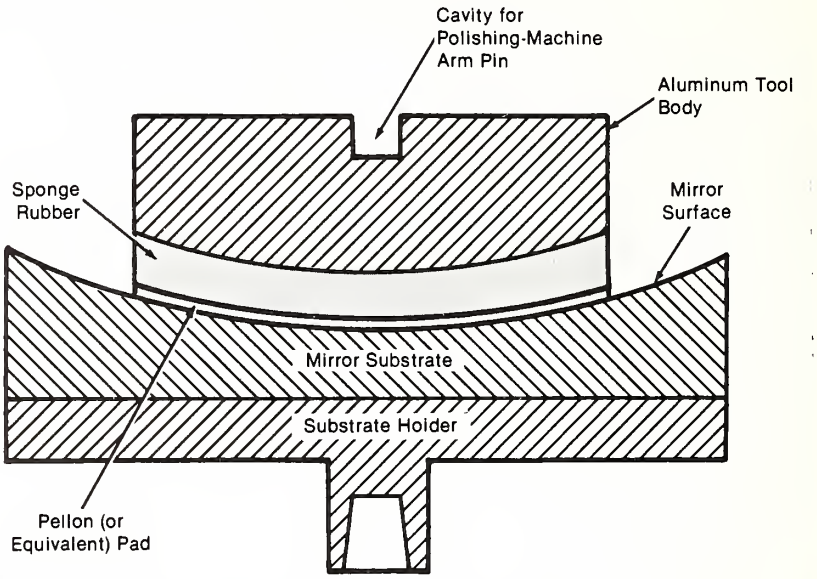
Removing Silicon Monoxide From Nickel Mirrors

Adherent fragments are detached by gentle polishing.

The combination of a polishing tool and polishing mixture is used to remove adherent fragments of silicon monoxide protective coatings from nickel/aluminum mirrors without altering the shapes or harming the polishes of the mirror surfaces. The polishing technique was developed to prepare stained mirrors for recoating to restore high reflectance.

A polished electroless-nickel-plated mirror is coated with vacuum-deposited aluminum to enhance its reflectance, then overcoated with glasslike silicon monoxide for durability. During extensive use, the surface becomes stained, losing reflectance. Before recoating, the surface layers are stripped off with a solution of sodium hydroxide, which penetrates through minute pores in the silicon monoxide and dissolves the aluminum. The silicon monoxide is insoluble and simply floats off the mirror surface as the aluminum is dissolved. However, fragments of the silicon monoxide adhere to the surface and must be removed because they cause unwanted scattering of light.

The polishing technique applies just enough force to remove the fragments. In contrast with conventional rigid tools, the new tool (see figure) is flexible: thus, it conforms to the existing mirror shape, rather than forcing it into a different, unwanted configuration. The tool is formed on an aluminum body with a diameter of about ⅔ that of the mirror. If the surface to be polished is convex or concave spherical, or planar, the tool body is machined to the mating concave, convex, or planar surface shape, respectively.



A **Polishing Tool With a Compliant Surface** conforms to the mirror surface. It applies just enough force to remove adherent silicon monoxide without damaging the mirror surface.

The tool surface is covered with sponge rubber ¼ in. (6 mm) thick, using a general-purpose adhesive (GC bond or equivalent). An adhesive-backed Pellon (or equivalent) pad is applied to the surface of the sponge rubber. The mirror can be used as a pressing tool for the polisher while the adhesive is curing.

The tool surface is saturated with a gently acting abrasive of three parts aluminum oxide (Linde B 0.05 μm or equivalent) and one part cream of tartar, with an abrasive additive of lathered barber's shaving soap, and with water as the abrasive carrier. The tool and mirror are set up on a conventional polishing machine. The eccentricity and the polishing force are adjusted to suit the location and degree of residual stain on the mirror surface.

This work was done by John J. Zaniewski of **Goddard Space Flight Center**. *No further documentation is available. GSC-13079 /TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
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NASA Tech Brief
National Aeronautics and Space Administration
Ames Research Center, Moffett Field, California

Licensing Opportunity

Solenoid Valve With Self-Compensation

Paired upstream and downstream seals balance sealing forces.

By using a dual upstream and downstream seal, a new solenoid-operated miniature shutoff valve provides self-compensation of the differential pressure forces that cause jamming or insufficient valve closure as in single-seal valves. Furthermore, the dual-seal valve is bidirectional. The normally closed valve shown in the figure operates reliably at pressures up to at least 1.5 MPa. By appropriate reversal of the solenoid and spring action, a similar normally open valve could be designed.

The valve simultaneously seals both the inlet and outlet tubes by pressing a single disk of silicone rubber against the ends of both. When the valve is open, the pressures in the inlet and outlet tubes and in the body of the valve are all approximately equal. Thus, when the spring closes the valve, there is no significant differential fluid-pressure force acting across the valve disk. The result is positive, nonjamming sealing action.

Since the moving parts of the valve are all located entirely within the fluid-flow region, no sliding seals are required, and leakage to the exterior of the valve should not occur even after prolonged use.

This work was done by Fritz H. Woeller and Yutaka Matsumoto of **Ames Research Center.** *No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center Refer to ARC-11620./TN

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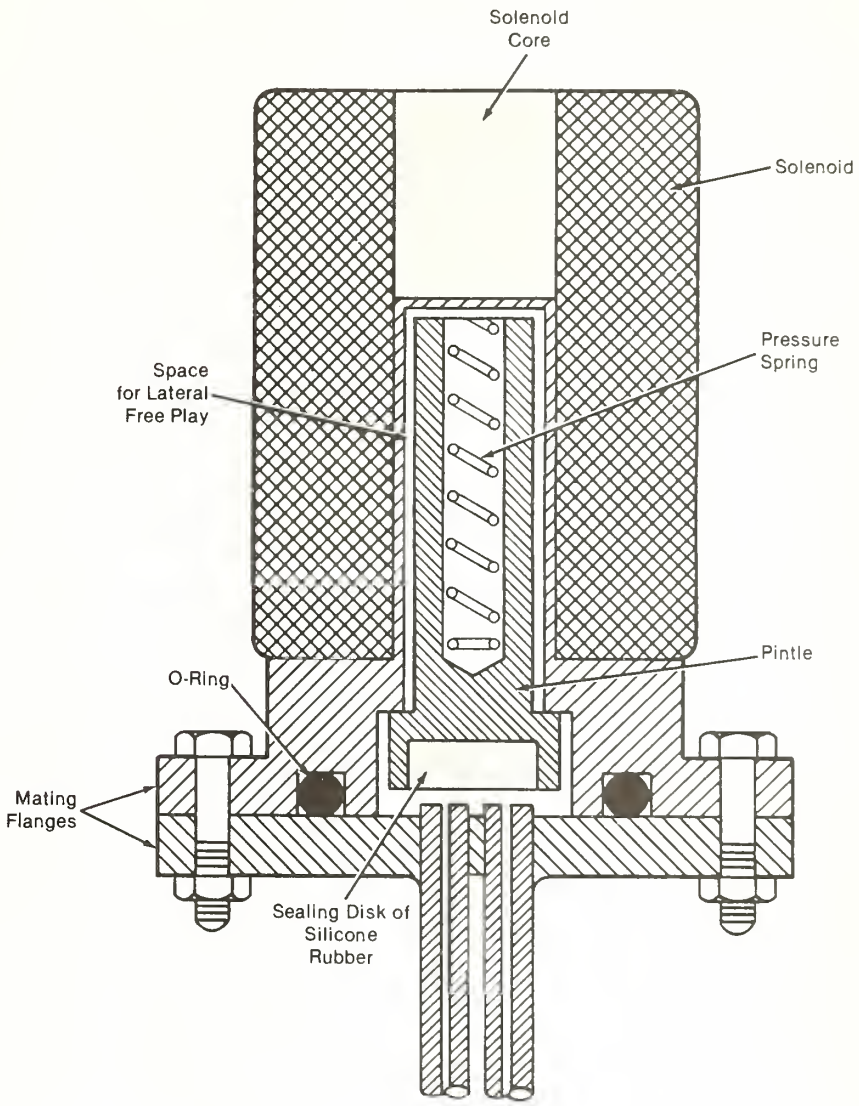

The **Solenoid Valve** achieves self-compensation of differential pressure forces by sealing both the inlet and outlet tubes with the same side of a disk of silicone rubber.

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Assembly-Line Simulation Program

Costs and profits are estimated for models based on user inputs.

The Standard Assembly-Line Manufacturing Industry Simulation (SAMIS) program was originally developed to model the manufacturing processes used in a hypothetical U.S. facility that manufactures silicon solar modules for use in electricity generation. The SAMIS program has been generalized to the extent that it should be useful for simulating processes in many different production-line manufacturing companies. SAMIS provides an accurate and reliable means of comparing alternative manufacturing processes. It can also be used to assess the impact of changes in such financial parameters as the costs of resources and services, inflation rates, interest rates, tax policies, and the required rate of return on equity.

The most important capability of SAMIS is its ability to estimate the prices a manufacturer would have to receive for its products to recover all of the costs of production and make a specified profit. To do so, it "constructs and staffs" a simulated company, based on a set of manufacturing-process descriptions developed by the user. The results of the simulation are financial reports that detail the direct and indirect requirements, including quantities and costs, of the processes that comprise the company.

Because of the large amount of data that may be needed to describe a company and its manufacturing processes, the user interface for SAMIS has received a great deal of design attention. Every available action and every datum has an associated "help" message. Menus and color are used to advantage.

SAMIS is available in two versions. The IBM 370 version, Release 4.0, is written in SIMSCRIPT II.5 with a central-memory requirement of approximately 2 megabytes. SAMIS was first developed in 1978; Release 4 has been available from COSMIC since 1982.

The IBM PC version of SAMIS is written in TURBO PASCAL, Version 2.0, and requires at least 256 kilobytes of random-access memory, a minimum of 1.5 megabytes of hard-disk space, an 8087 math coprocessor, and an IBM color-graphics adapter. Executable and source codes are provided. The IBM PC implementation of SAMIS, Release 6.0, includes the PC-IPEG program for rapid analyses of the effects of financial parameters on the product price; the SAMPEG mode of operation for rapid analyses of the effects of process parameters on the product price; and the full, thoroughly validated SAMIS simulation mode for detailed analyses. Release 6.0 also includes changes to accommodate the depreciation method in the accelerated cost recovery system (ACRS), and a cost-account catalog updated to 1985.

This program was written by Robert G. Chamberlain, Silvino Zendejas, and Shan Malhotra of Caltech for **NASA's Jet Propulsion Laboratory**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, NASA Resident Office-JPL Refer to NPO-16779/TN

FOR ADDITIONAL INFORMATION *CONTACT:*

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NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Process Sensor Developed to Measure Internal Temperatures in Extruded Aluminum

A process control sensor to rapidly measure the internal temperatures of extruded aluminum as it comes out of a die has been developed by the National Bureau of Standards (NBS) and the Extruded Products Division of the Aluminum Association. With improved temperature control at the extrusion press, manufacturers will be able to increase the production speed of extruded materials, prevent surface cracking, and improve product yield.

The sensor was produced under a cooperative research program, established in 1986, between the Commerce Department agency and the aluminum industry group to develop a process control sensor for the manufacture of extruded aluminum products. Of the more than 16.1 billion pounds of aluminum projected for shipment in 1987 by U.S. manufacturers, nearly one-fifth of the production will be extruded shapes, bars, pipe, and rods.

The new process control sensor was designed by Michael L. Mester, an Aluminum Association-sponsored researcher at the bureau, and by NBS scientists Drs. Arnold H. Kahn and Haydn N. G. Wadley.

It has been tested by the researchers at the Cressona Aluminum Company, Cressona, Pa., where its on-line performance at an extrusion press in a working mill repeated successful laboratory measurements. The scientists were assisted in the Cressona tests by Richard M. Harris, vice president for manufacturing, and a team of production engineers.

The new sensor can measure the body temperatures of extruded aluminum at 500 degrees Celsius to a depth of one-half the thickness of the material, and with an accuracy of 5 degrees Celsius.

Based on an electromagnetic concept, the sensor generates eddy currents in hot aluminum as it is extruded from a die. (Eddy currents are electrical currents induced in a metal by changing magnetic fields.) By measuring the properties of eddy currents in metal, it is possible to determine temperature. With the new sensor, electromagnetic signals from the extruded material are recorded by a computer and rapidly processed to show temperatures for on-line process control.

According to Wadley, NBS sensor research group leader, the process control device is the first non-contact method to accurately measure the body temperatures of extruded hot metals.

Mester points out that the sensor has potential in the production of non-magnetic steels, copper, and metal alloys. It also could be used in other manufacturing processes such as the rolling and drawing of metals.

Kahn explains that the automated system also is designed to measure the dimensions of extruded materials as they come out of the press. This additional capability could be used to provide information on die wear during extrusion runs, and for other dimensional sensor needs such as in hot isostatic pressing.

The testing of the prototype sensor on an extrusion press completes the first part of the multi-phase program between NBS and the Aluminum Association.

The program between NBS and the Aluminum Association is one of many such cooperative undertakings with in-

dustry at the bureau. In the metals area, a similar agreement between NBS and the American Iron and Steel Institute has produced a prototype ultrasonic sensor for detecting flaws in hot steel billets, and has made possible another ultrasonic sensor technique for reading internal temperature profiles in metals.

For Additional Information:

To discuss this effort further, contact:

Dr. Haydn Wadley, A167 Materials Building, National Bureau of Standards, Gaithersburg, Md. 20899; (301) 975-6139.

Materials

1198 Teaching Modules on Wood Engineering Design

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1200 Microcellular Foams Have Many Scientific Applications

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1202 Copolyimides With Flexibilizing Groups — Copolymers have improved flexibility, processability, and melt-flow characteristics. (Licensing Opportunity)

1203 Cotton-Fiber-Filled Rubber Insulation — Carbonization of fibers at high temperatures could improve strength and erosion resistance.

1204 Directional Solidification of Nodular Cast Iron — Cerium enhances the formation of graphite nodules. (Licensing Opportunity)

1205 Growing Single Crystals of Compound Semiconductors — Defects would be reduced by preventing melt/furnace contact and by suppressing convention. (Licensing Opportunity)

1206 High-Temperature Copolyimide Adhesive — Thermoplastic copolyimide polymer is made from inexpensive, commercially available materials.

1207 Thermal Stresses in Silicon-Web Growth — A suitable temperature distribution may yield a stress-free ribbon.

1208 Processable Polyimides Containing ATBN Elastomers — Void-free moldings are obtained without serious sacrifice in other properties. (Licensing Opportunity)

Testing & Instrumentation

1209 Theory for NDE Technique to Detect Flaws in Concrete

1210 Wear Test Apparatus Developed for Ceramics

1211 Screening Testing for Composite Pregregs

1212 Fatigue-Testing Apparatus for Metal Matrix Composites — Thermal and mechanical load cycling are simulated in realistic fatigue tests.

1213 Hardness Tester for Polyur — A rubber-hardness tester is modified and recalibrated.

Other items of Interest

1321 Physical Response of Flat Steel Plates to Drop-Hammer Impacts

United States Department of Agriculture

Research Technology
U.S. Forest Service

Teaching Modules on Wood Engineering Design

The Forest Products Laboratory of the U.S. Forest Service in cooperation with the University of Wisconsin-Extension, has completed the last in a series of teaching modules designed to help engineers and architects better understand the structural uses of wood.

Developed using a unique peer review approach designed by the Materials Education Council at Pennsylvania State University. *Wood: Engineering Design Concepts* is the fourth volume in the Clark C. Heritage Memorial Series on Wood.

Wood: Engineering Design Concepts and the series' three previous volumes are a resource of lecture material and tests for engineering and material science professors teaching about wood's utility in construction and design.

Volume I. *Wood: Its Structure and Properties*, 1981. discusses in nine modules the basic insights into the structure, treatment, and properties of wood. In Volume II. *Wood as a Structural Material.* 1982. both old and new wood materials and their uses as structural materials are described in eight modules.

Volume III, *Adhesive Bonding of Wood and Other Structural Materials.* 1983. has nine modules that cover the rapidly expanding application of adhesively bonded wood products and structures. Volume IV, *Wood: Engineering Design Concepts.* 1987. comprises eight modules that provide information and data on design of major structural members.

The Materials Education Council was instrumental in integrating the resources of the Educational Modules for Materials Science and Engineering (EMMSE) project in the Heritage series. The material for each of the volumes was reviewed by carefully selected educators. In workshops, the educators acted as students. doing homework and listening to lectures, and then critiqued the materials they had been presented. This peer group review helped ensure that the modules are both technically accurate and educationally appealing.

FOR FURTHER INFORMATION CONTACT:

The entire set of Heritage volumes can be ordered from the Materials Education Council. 110 Materials Research Laboratory Pennsylvania State University, University Park, PA 16802, for $62. Individual volumes are also available.

Electroforming With Nickel, Iron, and Aluminum

A manual has been prepared of the practical operating instructions for electroforming with the Watts-type nickel, iron, and aluminum baths. It contains the supposedly "secret" principles used by different manufacturers of electroformed parts. Detailed are the methods used to produce several types of electroformed shapes with lengths up to 30 in. and diameters as large as 8 in. The apparatus are described; the physical properties of electroplating baths and step-by-step plating operations are outlined; analyses of electroformed products is provided; the difficulties encountered in the electrolysis process are addressed; mandrel design is described; and the machining and grinding techniques used are defined. Also described is how to produce "steel" shapes from iron that has first been electroformed and then carburized on a TiC mandrel. Since the published material on electroforming is scattered and incomplete, the manual was prepared to gather the practical experience into a single source.

The manual is divided into three sections: nickel electroforming, iron electroforming, and aluminum electroforming. Some material is repeated in the different sections, but the organization is intended to make it easier to use this report as a laboratory manual for electroforming several types of shapes with the Watts-type nickel, iron, and aluminum baths. For ease of reference during plating and finishing operations, the manual is heavily footnoted and illustrated, and has a detailed table of contents. A general bibliography represents a search of the literature on electroforming.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.

NTIS order number: DE87-005589/NAC

Price code: A05

To discuss this effort further, contact

Mr. J. F. Lakner
Lawrence Livermore National Laboratory
U. S. Department of Energy
Livermore, CA 94550

Microcellular Foams Have Many Scientific Applications

Novel polymer foams with cell sizes a tenth to a thousandth that of typical foams have been made at Sandia National Laboratories. Many applications are being explored.

Possible uses for the new microcellular polymer foams include structural supports for high-energy physics experiments, supports for the catalysis of chemical reactions and for the exchange of ions, spaceborne comet-dust collectors, and filters.

A variety of medical applications, including artificial veins, artificial skin, and absorbable templates for delivery of controlled-release drugs are also possible. Some of these are now being explored with medical researchers.

Conventional foams—the polystyrene of a disposable coffee cup, for example—are composed of cells or air pockets about 100 micrometers in size, almost big enough to see with the unaided eye. Sometimes, however, the cell walls of such conventional foams have much smaller pores, or "microcells."

All microcells in new foams

The new foams being made at Sandia consist entirely of microcells. These microcells are one to three orders of magnitude smaller than the cells of conventional foams. The Sandia scientists have made polystyrene foams with a cell size as small as 0.1 micrometer in diameter, a thousandth the size of conventional polystyrene cells.

The cells are not only small but very uniform in size and very evenly distributed. This makes for a low-density, porous material that is very uniform and has a high surface area. Such a medium is attractive for many of the applications being considered.

"Every month or two we hear of another possible use for these kinds of foams," says Sandia scientist James H. Aubert. "And there might be lots of other applications we do not yet know of."

The research is being pursued by Aubert and Peter B. Rand, both of Sandia's Physical Properties of Polymers Division, and Alan Sylwester of the Chemistry of Organic Materials Division. Some parts of the work are in collaboration with colleagues at Los Alamos National Laboratory.

The technique for making the new foams is quite general, Aubert says. It can be applied to any polymer for which suitable solvents can be found. A solution of the polymer is made and then caused to undergo phase separation (to come out of solution) in a controlled way. The solvent is then removed by either freeze drying or extraction, leaving behind a microcellular polymer foam.

Thermodynamic variables controlled

The scientists have learned to gain control over many of the thermodynamic variables that are important in foam formation and that affect both foam morphology and cell size. This control has enabled them to make a variety of foams meeting specifications for many diverse applications.

Some of the first applications have been in physics experiments at the national laboratories. Scientists involved in development of inertial confinement fusion and a laboratory x-ray laser need a low-density porous material with small cell size. In some cryogenic inertial fusion targets, a microcellular foam would act as a sponge to hold liquid deuterium-tritium fuel in place for a precise fusion experiment.

In Sandia's work to study x-ray laser physics using a pulsed-power accelerator as an x-ray laser pump, a microcellular foam is used as the x-ray laser target. For this use the foams are ultra-low density (less than 6 milligrams per cubic centimeter, or 6/1,000th the density of water) microcellular foams. The foams are made from water-soluble polymers.

Another application being pursued is in catalysis. Many commercial chemical processes depend on catalysts. The Sandia scientists are making carbonized microcellular foams that have very high surface areas. These may prove useful as supports for catalysts, the large surface area contributing to the speed and effectiveness of the reactions.

Lots of medical applications

Perhaps most surprising are the biomedical possibilities. "There appear to be lots of medical applications for porous polymer foams," says Aubert. "Physicians tell us porous or high-surface-area media are very desirable for a number of things."

The possibility of using the foams in vascular grafts, or artificial veins, is being explored in a collaboration with Dr. Paul Mann of the University of New Mexico (UNM) School of Medicine. Mann has learned how to grow endothelial cells, which coat the body's entire vascular system, on porous polymers. This leads to the possibility of artificial veins. A vein-shaped foam material could be made from a bio-compatible polymer. Then endothelial cells could be grown on it.

Aubert says medical people at UNM have suggested a lot of other uses, such as controlled drug release (because of the high surface area), nerve regeneration pathways, artificial skin, and many others.

The Sandia scientists have also recently met with

representatives of the Jet Propulsion Laboratory (JPL) to discuss use of microcellular polymer foams in the collection of comet dust. Comet dust is of great scientific interest because comets date back to the beginning of the solar system.

Future comet fly-by missions are envisioned in which the spacecraft would collect dust and rendezvous with the space shuttle for return to earth. Foams have proved more successful for dust collection than solid, liquid, or even gas traps.

Sandia has agreed to provide JPL a variety of microcellular foams for its evaluation. One, polyacrylonitrile, has a cell size of about 0.5 micrometer. The hope is that such foams will be able to capture comet dust in the size range of 10 to 100 micrometers, Aubert says.

FOR ADDITIONAL INFORMATION

Public Information Division,
Code 3161,
Dept. of Energy,
Sandia National Laboratories,
Albuquerque, NM 87185-5800
(505) 844-4207.
Refer to announcement 22, No. 6

NASA Tech Brief
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

Application of Powdered Resin for Foam Insulation

Electrostatic spraying and heating replace cutting and gluing.

A process has been developed to apply the necessary insulation to valves, fittings, lines, etc. on such space vehicles as the Centaur rocket stage. The new process can replace the state-of-the-art process in which insulation (often of polyurethane) is foamed in molds and sold to the user in blocks and sheets that must be cut, fit, and bonded to the parts to be insulated. This is a cumbersome and expensive process, and some of the foam materials outgas and burn, generating smoke and toxic gases.

In the new process, electrostatic equipment is used to apply powdered polyimide resin directly to the part to be insulated. The part is then heated to the resin-foaming temperature; the resin foams and adheres to the part. The thickness of the final insulation is controlled by the amount of powdered resin applied to the part. The resulting excellent insulation will not emit smoke or toxic gases, even when exposed to an open flame.

This work was done by Glenn R. Morris of General Dynamics Corp. for **Lewis Research Center**. *No further documentation is available.*
LEW-14147 /TN

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NASA Tech Brief
National Aeronautics and Space Administration
Langley Research Center, Hampton, Virginia

Licensing Opportunity

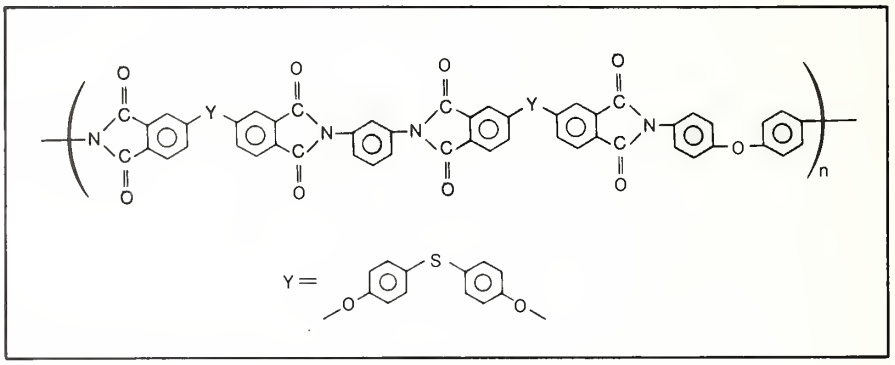
Copolyimides With Flexibilizing Groups

Copolymers have improved flexibility, processability, and melt-flow characteristics.

Aromatic polyimides are generally difficult to process because they exhibit only a limited degree of flow even at high temperatures and when subjected to high pressure. Because aromatic polyimides possess such desirable properties as good thermal stability, resistance to solvents, and high glass-transition temperature, there is a definite need for readily processable varieties. In the current technique, copolyimides are derived from the reaction of aromatic dianhydrides with a meta-substituted phenylene diamine and a bridged aromatic diamine. The incorporation of meta-substituted phenylene diamine derived units and bridged aromatic diamine derived units into the linear aromatic polymer backbone results in a copolyimide of improved flexibility, processability, and melt-flow characteristics.

Three copolyimides of varying copolymer molar ratios were prepared using three dianhydrides. The dianhydrides and diamines were dissolved in an inert solvent at a temperature between 10 and 30 °C. The reaction was allowed to proceed until a solid poly(amide-acid) soluble in the solvent was formed. The poly(amide-acid) was separated from the solvent and heated at 150 to 400 °C to form a solid copolyimide.

The copolymers thus formed consist essentially of two recurring polyimide moieties, one comprising an aromatic dianhydride derived unit and a bridged diamine derived unit and the other comprising an aromatic dianhydride derived unit and a meta-substituted diamine derived unit (see figure). The two diamine derived units are flexibilizing groups, which, when combined and incorporated into the backbone of a linear aromatic polyimide, lead to unexpected synergistic improvements in softening, thermoplastic, and flow behavior of the resulting copolymers.



A **Copolyimide** of the new type exhibits synergistic improvements in flow properties due to flexibilized diamine-derived units incorporated into the polymer backbone.

This technique produces copolyimides with a combination of flexible linkages that cause the polymers to exhibit flow properties that make them particularly well suited for use in a wide range of products including adhesives, molding resins, laminating resins, dielectric coatings, and protective coatings. These improved properties make the copolymers especially useful as thermoplastic hot-melt adhesives.

This work was done by Terry L. St. Clair, Harold D. Burks, Donald J. Progar, and K. Mason Proctor of **Langley Research Center.** *Further information may be found in NASA TM-86416 [N85-31296/NSP], "Synthesis and Characterization of Copolyimides with Varying Flexibilizing Groups."*

Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, [A03]

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center
Refer to LAR-13354./TN

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REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Cotton-Fiber-Filled Rubber Insulation

Carbonization of fibers at high temperatures could improve strength and erosion resistance

Cotton linters (short cotton fibers) are being tested as a replacement for the asbestos filler currently used in rubber insulation in solid rocket motors. The use of asbestos must be discontinued because it poses a serious health hazard to those exposed to it. The cotton-filled rubber insulation may have industrial uses; for example, in some kinds of chemical- or metal-processing equipment, hoses, and protective clothing.

A carbon-fiber-filled version of the insulation has already demonstrated high resistance to erosion in this application, but it is expensive and its physical properties make it difficult to use. It is hoped that satisfactory performance can be achieved more economically by taking advantage of the high-pressure, high-temperature, and relatively reducing atmosphere within the combustion chamber of the rocket motor to carbonize the fibers in the insulation. The question is whether the carbonized cotton fibers will provide the strength and erosion resistance of carbon fibers by forming a strong, thermally protective char layer on the surface of the insulation.

To test the concept, cotton linters are being processed as fillers in various rubber matrices and evaluated as to physical properties, processing properties, and erosion resistance. An alternative fiber, polyacrylonitrile, will also be tested. Test conditions will match the combustion-chamber gas flow and gas-temperature regime of a solid rocket motor burning the solid propellant currently used in the Space Shuttle solid rocket boosters.

This work was done by Floyd A. Anderson of Caltech for **NASA's Jet Propulsion Laboratory**.
NPO-16868 /TN

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NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Licensing Opportunity

Directional Solidification of Nodular Cast Iron

Cerium enhances the formation of graphite nodules.

Preliminary experiments in the directional solidification of cast iron have shown a quantitative correlation of the graphite microstructure with the growth rate and the thermal gradient, with sufficient spheroidizing element to form spheroidal graphite under the proper thermal conditions. The experimental approach enables the use of directional solidification to study the solidification of spheriodal-graphite cast iron in low gravity. Because directional solidification can often be used to form alloys with regular composite structures, it may be possible to form new structural materials from nodular (spheroidal-graphite) cast iron.

Previous attempts at directional solidification of spheroidal cast iron failed, in part because magnesium was used as the spheroidizing element. In addition, holding the material in the molten state reduced the level of spheroidizing elements below the minimum required to produce spheroidal graphite.

The experiments were performed in a standard Bridgman-type solidification furnace, which includes a cylindrical crucible containing the sample, surrounded by a cylindrical heating element on top of a quenching block. The growth rate and thermal gradient during solidification can be independently controlled by the choice of the speed at which the furnace moves along the longitudinal crucible axis.

Nodular cast iron was directionally solidified under the following conditions:

- Cerium was substituted for magnesium as a spheroidizing element.
- The holding temperature was kept below 1,350 °C.
- Solidification was done under an argon atmosphere.

The study of directionally solidified samples should suffice to establish quantitative relationships between the microstructure of the cast iron, its composition, and the ratio of the temperature gradient to the growth rate during solidification. Previous studies using wedge-chill techniques provided only qualitative information on the effects of cooling rates on structure.

This work was done by P. A. Curreri of **Marshall Space Flight Center** *and D. M. Stefanescu and J. C. Hendrix of the University of Alabama. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center Refer to MFS-28015 /TN

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NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Licensing Opportunity

Growing Single Crystals of Compound Semiconductors

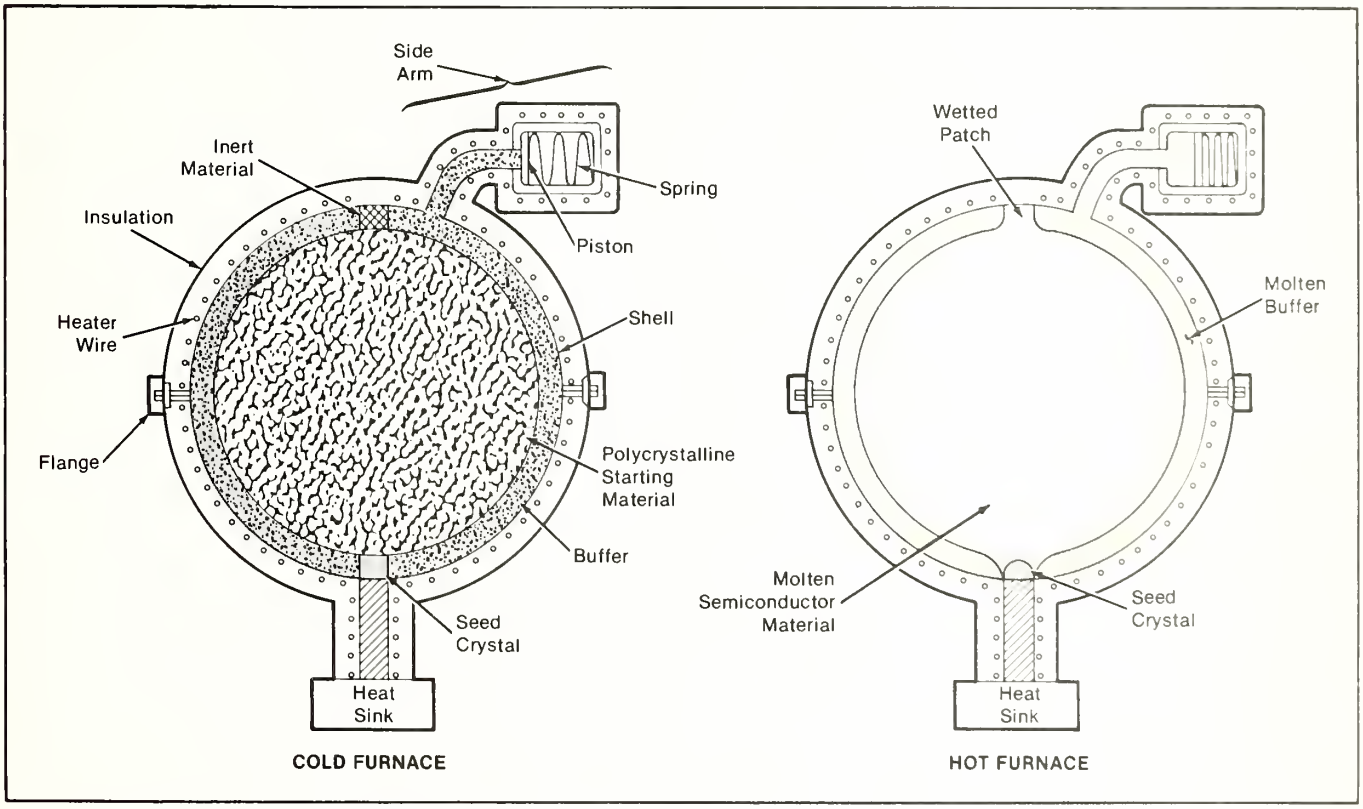
Defects would be reduced by preventing melt/furnace contact and by suppressing convention.

Large crystals of compound semiconductors with few defects would be grown by a proposed new method. Such materials as gallium arsenide and cadmium telluride would be produced, perhaps with a quality suitable for very-large-scale integrated circuits or for large focal-plane arrays of photodetectors. The method can be used on a small scale in Earth gravity, but would need microgravity to provide crystals large enough for industrial use.

The method reduces thermal strain induced in the semiconductor material by the container as the material solidifies during growth. Such strain is the primary cause of defects in contained growth. The method employs a buffer layer between the semiconductor material and the container. The buffer layer melts at a lower temperature than does the material but is immiscible with the material and isolates it from the effects of the container wall.

A spherical furnace shell would serve as the container (see figure). The shell has a high thermal conductivity so that it provides a uniform-temperature boundary for the semiconductor material. Resistance heating wires surround the shell. An outer layer of insulation prevents excessive heat loss from the furnace. The inside of the shell is coated with a refractory material.

The charge is prepared by casting or pressing the semiconductor into a sphere



A **Polycrystalline Sphere of Gallium Arsenide**, or other compound semiconductor to be processed, rests in a furnace. After heating, the molten sphere floats in a layer of molten buffer material, which isolates the semiconductor from the furnace wall. During cooling, a spherical solid front advances from the seed to the top of the furnace.

slightly smaller than the inside of the furnace. The buffer material, in powder form, is pressed around the sphere. Holes are left in the buffer coating at the poles to accommodate a seed crystal (at the bottom) and a support plug (at the top).

The seed crystal — a single crystal of the semiconductor material — is inserted in a heat sink in the bottom half of the furnace shell. The charge is then placed in the bottom half of the shell, and the top half of the shell is assembled over it. The support plug, anchored at the center of the top shell, fits in the top hole in the buffer layer. The plug is made of an inert material that is wettable by the molten charge.

The furnace is heated so that first the buffer, then the charge, melts. The seed is cooled through the heat sink so that it remains solid. At equilibrium, the semiconductor melt is surrounded by a thin layer of the buffer melt except at the seed and support locations. When the furnace has been heated to equilibrium, single-crystal growth is begun in the semiconductor melt by slowly lowering the furnace temperature and adjusting the heat flow from the seed.

Expansion and contraction during heating and subsequent cooling are taken up by the flow of the buffer into and out of a side arm. This flow protects the growing or grown crystal from container-induced strains. The side arm also includes a spring-loaded piston that serves as a pressure regulator. It applies enough pressure to the semiconductor melt to prevent evaporation of components and thus maintains the required composition.

The crystal grows in a spherical shape that is tangent to the furnace wall in the vicinity of the seed crystal. The convexity of the growing crystal further reduces trapping of defects, tending to push them away from the solidifying mass.

Defects are further reduced because convection created by surface-tension gradients in the melt and buffer is suppressed: the uniform shell temperature minimizes lateral temperature gradients at this liquid/liquid interface. In addition, the thinness of the buffer layer and its wetting of the shell tend to dampen flow.

This work was done by Robert J. Naumann, Sandor L. Lehoczky, and Donald O. Frazier of **Marshall Space Flight Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center Refer to MFS-28137. /TN

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NASA Tech Brief
National Aeronautics and Space Administration
Langley Research Center, Hampton, Virginia

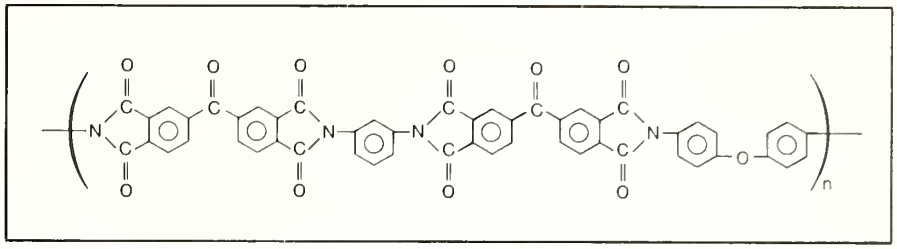
High-Temperature Copolyimide Adhesive

Thermoplastic copolyimide polymer is made from inexpensive, commercially available materials.

Thermoplastic polyimides show potential for use as matrix resins and adhesives for aircraft applications. One such thermoplastic polyimide, LARC-TPI, was developed at Langley Research Center in the late 1970's. The thermoplastic behavior of this polymer has been attributed primarily to the flexibility of the aromatic diamine used in its preparation: 3,3′-diaminobenzophenone, a meta-linked, bridged diamine, which was not commercially available at that time and which is now generally not available at a reasonable cost. Therefore, a program was begun to find a way to prepare a thermoplastic polyimide with properties similar to those of LARC-TPI using only commercially available materials.

The system that shows the most promise to date is a random copolyimide with the structure shown in the figure. The copolyimide, designated STPI/LARC, was prepared from the reaction of 3,3′4,4′-benzophenonetetracarboxylic dianhydride (BTDA), equimolar quantities of *m*-phenylenediamine and 4,4′-oxydianiline, and a small amount of phthalic anhydride to control the molecular weight. The incorporation of two types of flexibilizing diamines in the polymer affords a polyimide with thermoplastic properties and adhesive performance similar to those of LARC-TPI.

Test data on a commercially available LARC-TPI and on the experimental STPI/LARC show both polymers to possess exceptional lap shear strengths at room temperature and at elevated temperatures up to 204 °C, both before and after aging at 204 °C. However, the LARC-TPI strengths were, in general, higher than the corresponding STPI/LARC strengths. After exposure to boiling water for 72 hours, bonded specimens of both polymers exhibited similar percentage losses of strength in tests at room temperature and at 177 °C. In contrast, when tested at 204 °C after the exposure to boiling water, the STPI/LARC retained a much higher percentage of its original strength than did the LARC-TPI (68-percent vs. 40-percent retention). This phenomenon was most likely the result of STPI/LARC having a glass-transition temperature higher than that of LARC-TPI (283 °C vs. 260 °C).



This Random Copolyimide, called STPI/LARC, is prepared from commercially available materials. It is being investigated for possible use as an adhesive or matrix resin for aircraft applications.

An attractive feature of the STPI/LARC is that it is prepared from relatively inexpensive, commercially available chemicals. Therefore, this flexible, thermoplastic copolyimide shows considerable potential as an adhesive — based on the results of this initial study and on its ease of preparation and relatively low cost.

This work was done by Donald J. Progar, Terry L. St. Clair, Sharon E. Lowther, and Karen S. Whitley of **Langley Research Center**. *Further information may be found in NASA TM-86447 [N85-31297/NSP], "STPI/LARC: A 200 °C Polyimide Adhesive."*

Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, [A03]
LAR-13509 /TN

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NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Thermal Stresses in Silicon-Web Growth

A suitable temperature distribution may yield a stress-free ribbon.

A mathematical model represents the thermomechanical behavior of a solid web of rectangular cross section as it is pulled from a melt of the same material. Although intended for application to the growth of silicon webs or ribbons, the model is general enough to be applicable to other materials as well. The model shows that a suitable temperature distribution may result in a stress-free ribbon.

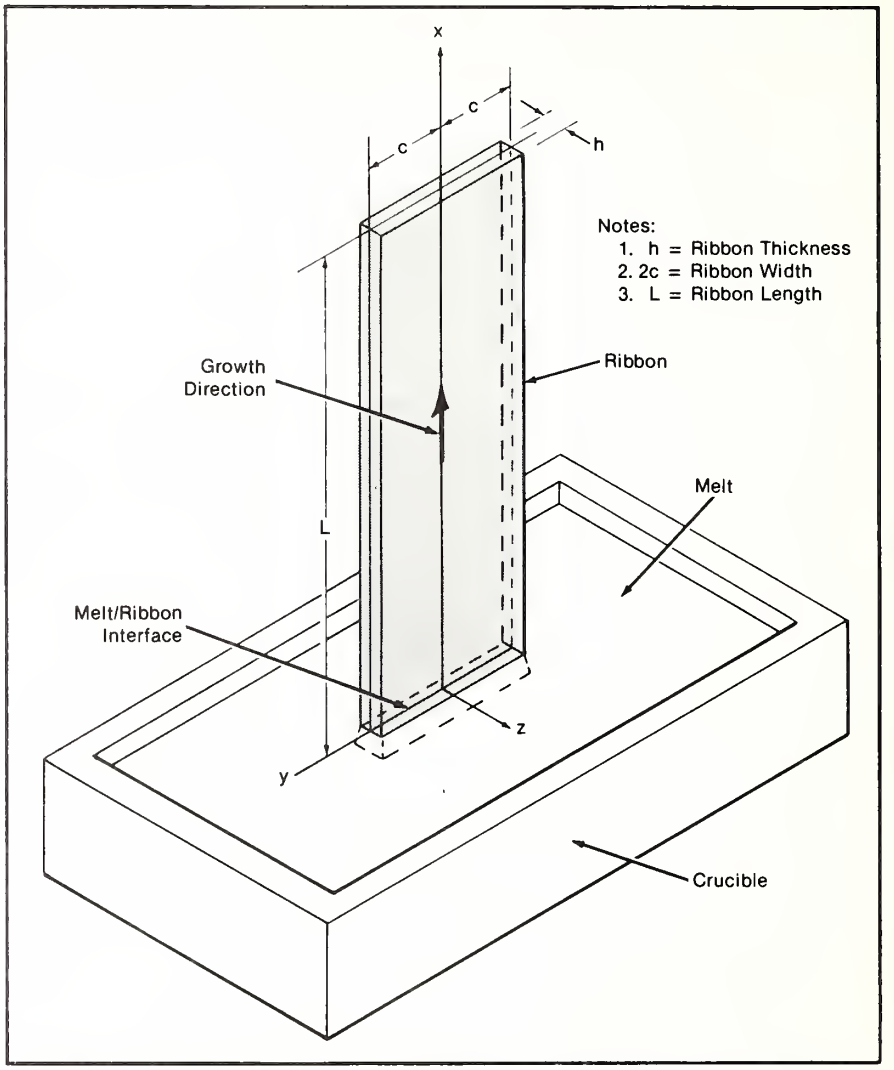
The ribbon (see figure) is taken to be sufficiently thin to justify the approximation that there is no thermal gradient through the thickness (z direction). The temperature is allowed to vary only along the width (y direction) and length (x direction) of the growing web. The solid material is assumed to be orthotropic, with temperature-dependent coefficients of thermal expansion α_x, α_y, and α_{xy}.

The thermal strains cause thermal stresses, which give rise to plastic, elastic, and creep strains. The relationships among the stresses and strains is expressed in a matrix equation. Considering only the situation after the initial thermal transients have dissipated and the ribbon is growing at a steady rate, the equation is put in its steady-state form.

The steady-state equation has a zero-stress solution, which can be realized in one or more ways depending on the temperature distribution and the properties of the material. In particular, the equation shows that the ribbon will be free of thermally induced stresses if the material can deform freely and if the thermal loading is such that the thermal strains satisfy the strain-compatibility equations. Cases in which the zero-stress conditions are satisfied include the following:

- The thermal-expansion coefficients are independent of temperature and position, there are no restraints against free deformations, and the temperature either varies linearly with position or is uniform; and
- The thermal-expansion coefficients are independent of temperature, the material is isotropic ($\alpha_x = \alpha_y = \alpha$; $\alpha_{xy} = 0$) and homogeneous and $\nabla^2 T = 0$, where T = temperature.

In the second case, assuming that the temperature at the edge of the ribbon is prescribed to be that required by the manufacturing process, if the temperature distribution within the ribbon can be made to satisfy $\nabla^2 T = 0$, the ribbon will grow without stress. The required distribution is found by solving $\nabla^2 T = 0$ as a boundary-value problem.



A **Conceptual Ribbon of Rectangular Cross Section** is pulled from a melt. This simplified configuration is used to calculate the thermal conditions for a stress-free ribbon.

This work was done by Ben K. Wada of Caltech for **NASA's Jet Propulsion Laboratory** *and Senol Utku and Sujit Kumar Ray of Duke University. NPO-16824 /TN*

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NASA Tech Brief

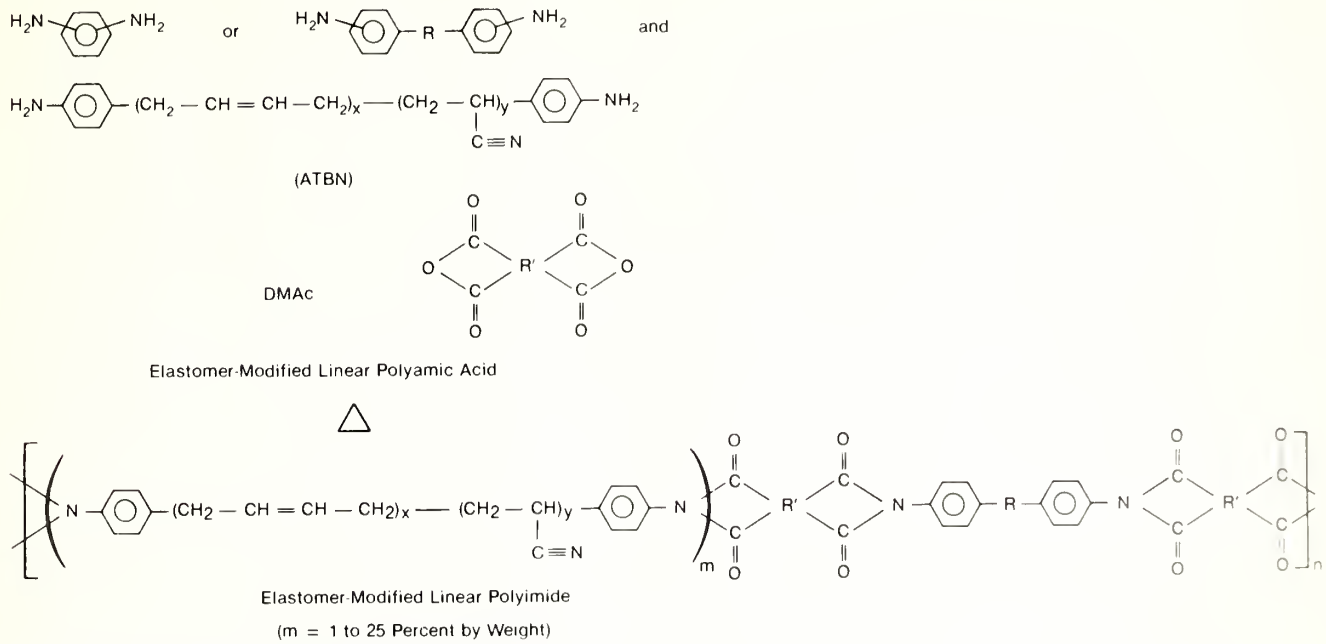
National Aeronautics and Space Administration

Langley Research Center, Hampton, Virginia

Licensing Opportunity

Processable Polyimides Containing ATBN Elastomers

Void-free moldings are obtained without serious sacrifice in other properties.



The **Elastomer-Modified Linear Polyamic Acid** is prepared in a reaction at room temperature, then polymerized by heating.

A new synthesis produces a high-temperature linear aromatic polyimide that can be processed in the imide form to yield tough, void-free components without serious sacrifice in other properties. Linear aromatic condensation polyimides are materials of prime choice for use as adhesives, composite matrix resins, films, coatings, and/or moldings where durability at temperatures as high as 200 to 300 °C is needed. Because of their outstanding properties, they are finding increasing use in aircraft and spacecraft applications.

A major drawback hindering wider use of linear polyimides is that they are extremely tedious to process compared to other engineering plastics. Traditionally, a fully cured linear aromatic polyimide is intractable. Polyimide adhesives, laminates, or molded parts are generally processed in the amic acid form and later converted to the fully cured polymer. Because of the volatiles generated during final cure, the preparation of large, void-free components becomes exceedingly difficult, if not impossible.

By incorporating relatively small amounts of amine-terminated butadiene/acrylonitrile (ATBN) elastomer into the linear polyimide backbone, an otherwise hard-to-process polymer can be processed. The preparation of the elastomer-containing amic acid prepolymer involves the reaction of an aromatic diamine and an aromatic ATBN elastomer with an aromatic dianhydride in a polar solvent such as N,N-dimethylacetamide (DMAc) at room temperature. The reaction scheme is shown in the figure, where R is a divalent radical, R′ is an aromatic tetravalent radical, x is an integer of 1 or greater, and y is an integer of 0 or greater.

Although the aromatic diamine 4,4′-oxydianiline was specified, other aromatic diamines could be used. Similarly, other ATBN rubbers could be employed, and other dianhydrides are applicable in the synthesis. In addition to DMAc, other solvents are suitable for preparing the elastomer-modified polyamic acid resin.

The conditions under which the elastomer-modified polyimide powder was processed to form a void-free molded part [250 °C temperature, 4,000 to 6,000 psi (28 to 41 MPa) pressure] were found to be optimum for this particular system. Optimum conditions may vary depending upon the aromatic diamine, the elastomer, the dianhydride, or the solvent used.

A control polyamic acid resin, BTDA + ODA, containing no elastomer was prepared, precipitated, and staged to the imide prior to processing. The control molding powder did not flow. A second control powder sample crumbled as it was removed from the mold. It is evident that the presence of the ATBN

elastomer in the polyimide matrix makes possible its processing, enhancing its ability to melt and flow. It is anticipated that the ATBN-modified polyimide of this synthesis will prove useful as a means of improving processing capability in the preparation of polyimide moldings, molded laminates, adhesive joints, or coatings for applications on aircraft and spacecraft, or for any other commercial applications where lightweight, high-temperature materials are required.

This work was done by Anne K. St. Clair and Terry L. St. Clair of **Langley Research Center** *and Stephen A. Ezzell of Virginia Polytechnic Institute and State University.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center. Refer to LAR-13178/TN

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NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Theory for NDE Technique to Detect Flaws in Concrete

Two papers in the July/August 1987 Journal of Research of the National Bureau of Standards (Vol. 92, No. 4) explain the theory behind a nondestructive technique developed by researchers in the NBS Center for Building Technology to detect flaws in concrete. Known as "impact-echo," the technique works on the same principle as the sonar pings used to locate and determine the depth of a submarine. An impact on the concrete generates sound waves which are reflected by flaws inside the concrete. A receiver mounted on the surface of the concrete picks up the reflections' or echoes. The location of a flaw is determined by measuring how long it takes to receive the reflected echo. Parallel papers by the same authors (Sansalone, Mary; Carino, Nicholas J.; and Hsu, Nelson N.), "A Finite Element Study of Transient Wave Propagation in Plates" and "A Finite Element Study of the Interaction of Transient Stress Waves with Planar Flaws," provide an understanding of how the waves propagate in the concrete and how they interact with flaws. Two additional papers describing computer simulations performed by the research team to help interpret impact-echo results will be featured in an upcoming issue of the Journal.

For Additional Information:

Copies of the papers are available from the Structures Division, B162 Building Research Bld9., National Bureau of Standards, Gaithersburg, Md. 20899, 301/975-6048.

NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Wear Test Apparatus Developed for Ceramics

Existing test methods to measure the friction and wear of metals are not designed to study the performance of advanced ceramics used in heat engines and other high temperature environments because the material properties of ceramics are significantly different from steel. With ceramics. contact temperatures up to 2000 degrees Celsius may occur. At these high temperatures. the low thermal conductivity and diffusivity of ceramic materials can generate large temperature gradients in conventional test devices that obscure information on the friction and wear of advanced ceramics. NBS has developed a new high- temperature controlled atmosphere ceramic wear test facility that features control of temperature to I500 degrees Celsius. The facility also permits researchers to study various gaseous environments as well as the chemical vapor deposition of high-temperature lubricants.

For Additional Information:

For information on the new ceramic wear test facility' which is available for cooperative programs with industry, government, and universities, contact:

Dr. Said Jahanmir, A215 Metrology Building, National Bureau of Standards, Gaithersburg, Md. 20899, 301/975-3671.

Screening Testing for Composite Pregregs

The physical, chemical and ultimate mechanical properties of high performance carbon fiber reinforced composites are dependent on the quality of prepreg utilized and also how effectively the curing reactions were performed. Therefore, a knowledge of the curing reaction process and condition of the epoxy matrices is essential for producing acceptable parts. High pressure liquid chromatography (HPLC), Rheometrics mechanical spectrometry (RMS), dielectric spectrometry (DS), and differential scanning calorimetry (DSC) analyses were used to assess the quality of one prepreg.

The experimental results indicated that the RMS, HPLC and DS methods can be used to assess the degree of advancement. DSC can be used to distinguish between as received prepreg and aged prepreg; however, from the DSC data, it was difficult to determine the degree of advancement. Acceptable parts were fabricated from preforms aged at -31°C over 397 days.

Several parts were produced from preforms aged under the same conditions as those used for analytical evaluations. The test results indicate that acceptable parts can be produced from preforms aged at room temperature in high or low humid conditions for 19 days or less. Above that aging period, the viscosity of the preform resin (878 poise or higher at 130°C) became too high to produce acceptable parts.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.

NTIS order number: DE87-004557/NAC

Price code: A03

NASA Tech Brief
National Aeronautics and Space Administration
Lewis Research Center, Cleveland, Ohio

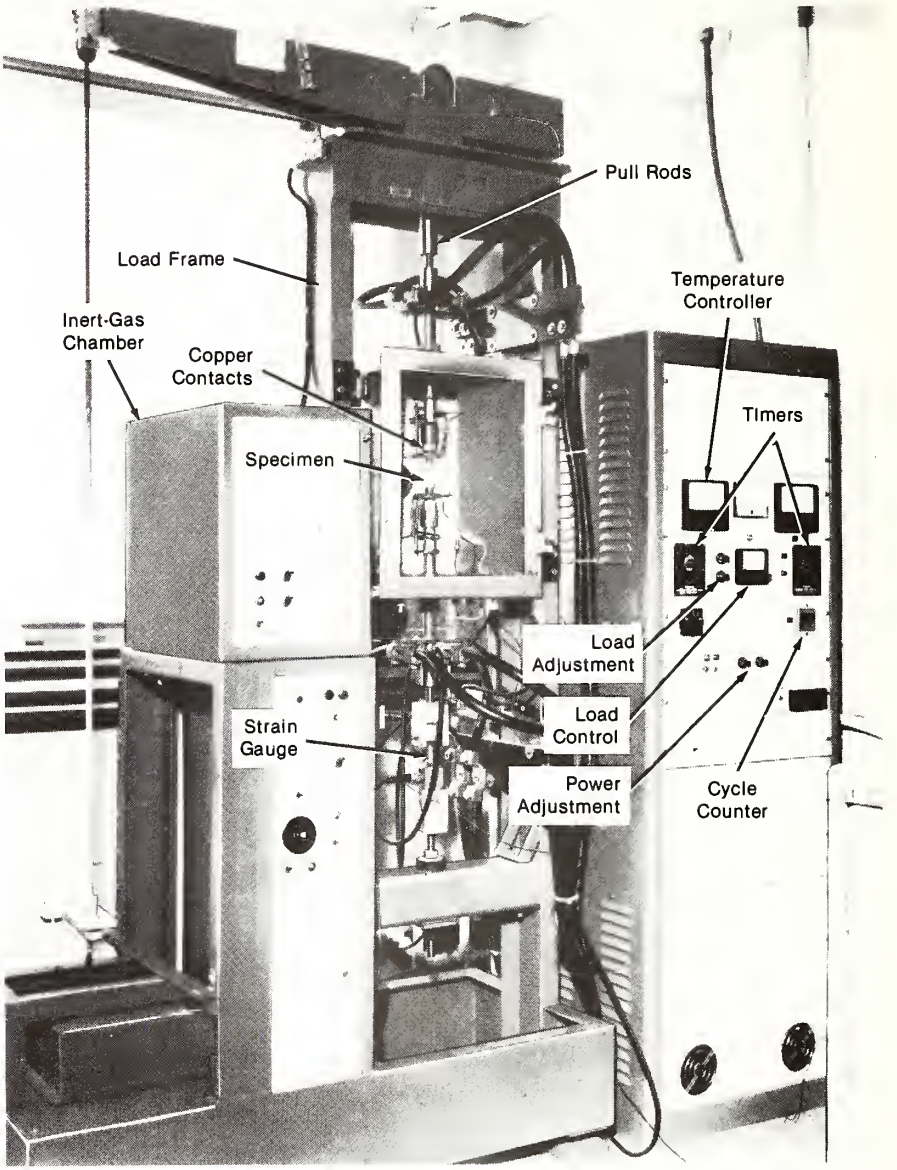
Fatigue-Testing Apparatus for Metal Matrix Composites

Thermal and mechanical load cycling are simulated in realistic fatigue tests.

Metal matrix composites have demonstrated a potential for use as high-temperature structural materials. The successful application of these materials often depends on their ability to withstand cyclic loading. Thermal/mechanical fatigue is one of the primary failure modes considered in the design analysis of high-temperature components. In the testing of these materials it is desirable to simulate, as closely as possible, the actual conditions of use. A thermal/mechanical fatigue-test facility was thus required for the simulation of the loading and environmental conditions projected for a metal matrix composite component during use.

The efficient joining of metal matrix composite components to supporting structures is a major concern facing users of these materials. A need exists to evaluate the thermal/mechanical fatigue behavior of composite/metal joint attachments and to simulate as closely as possible the conditions the joint attachments will experience in service.

The Lewis Research Center has designed and developed two thermal/mechanical fatigue test facilities, one to test metal matrix composite specimens at temperatures up to 2,600 °F (1,430 °C) and another to test composite/metal attachment bond joints at temperatures up to 1,400 °F (760 °C). The thermal/mechanical fatigue facility (see figure) designed for testing metal matrix composites permits specimen-temperature excursions from room temperature to 2,600 °F (1,430 °C), with controlled heating and loading rates. A strain-measuring device measures the strain in the test section of the specimen, during each heating and cooling cycle, with superimposed loads. Data are collected and recorded by a computer.



This **Thermal/Mechanical Fatigue-Testing Apparatus** simulates the cyclic loads that cause fatigue in metal matrix composites and composite/metal joint attachments.

The second facility was designed to test composite/metal attachment bond joints and to permit heating to a maximum temperature of 1,400 °C (760 °C) within 10 min and cooling to 300 °F (150 °C) within 3 min. A computer controls the specimen temperatures and load cycling. This facility has unique capabilities not found in other laboratories.

This work was done by Leonard J. Westfall and Donald W. Petrasek of **Lewis Research Center**. *Further information may be found in NASA TM-87187 [N86-15378/NSP], "Thermal-Mechanical Fatigue Test Apparatus for Metal Matrix Composites and Joint Attachments."*

Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, [A02]
LEW-14457 /TN

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NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Hardness Tester for Polyur

A rubber-hardness tester is modified and recalibrated.

A rubber-hardness tester (durometer) has been modified for use on rigid polyurethane foam. Previously, the inspection of parts made of rigid polyurethane foam involved subjective criteria — for example, a part was rejected if the color was lighter than normal or the part felt spongy. The modified tester provides an objective basis for the evaluation of improvements in foam manufacturing and inspection. A typical acceptance criterion requires a minimum hardness reading of 80 on the modified tester.

The tester (see Figure 1) has a 1-cm^2 spring-loaded pressing foot. In use, the tester is pressed onto the sample until the base of the instrument is flush with the material surface. The force exerted by the material on the foot is indicated on the dial: this is the hardness reading. In the unmodified instrument, the dial reading varies linearly from 0 at a minimum force (preload) of about 88 g weight (0.86 N) to 100 at a force of 142 g weight (1.37 N). For proper operation, the material must be at least ¾ in. (20 mm) thick.

By trial and error, increased values of spring stiffness and preload were selected so that the tester gave hardness readings

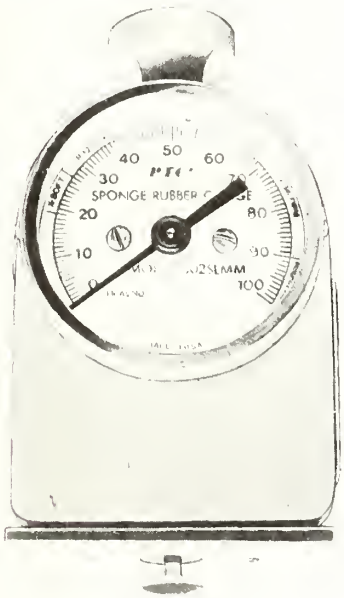


Figure 1. This **Durometer** is pressed into rubber or other resilient material to measure its hardness.

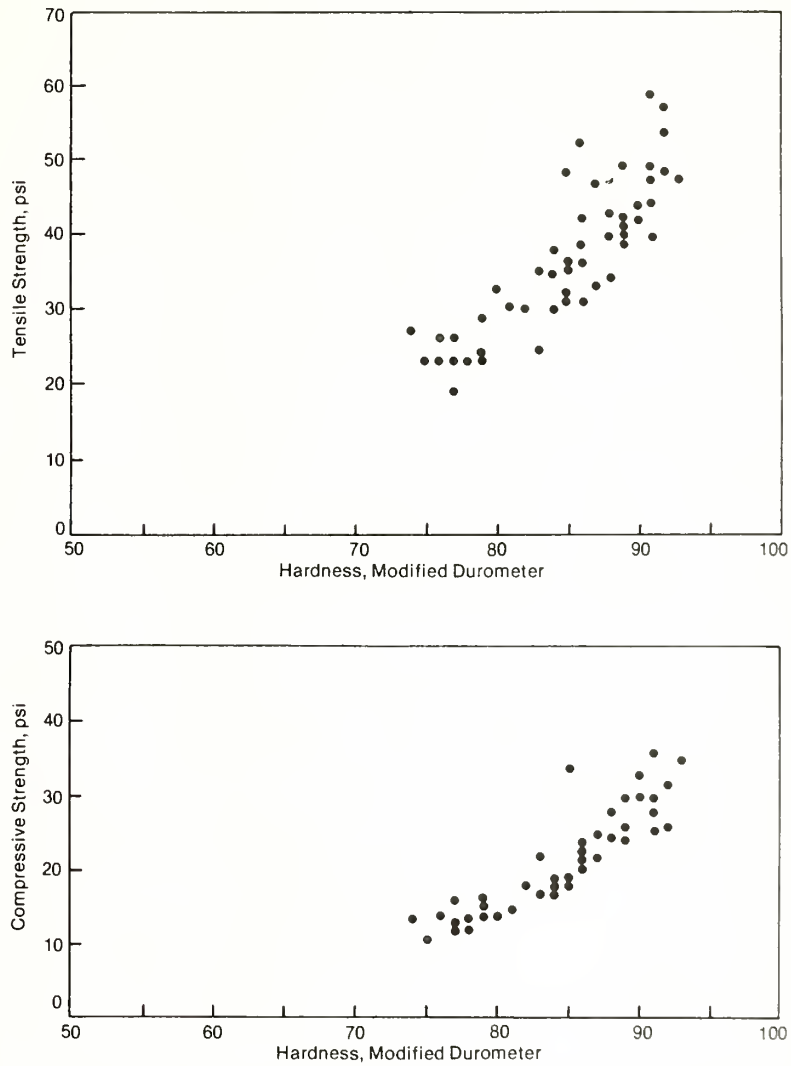


Figure 2. The **Tensile and Compressive Strengths and Hardness** were measured on samples of a commercial polyurethane foam that were prepared under different conditions.

at 75 to 95 percent of full scale with PDL-4034 (or equivalent) foam. The calibration plot of the modified tester shows a preload of about 0.25 lb (about 1 N) and a full-scale reading at a force of about 5.6 lb (about 25 N).

With adequate correlation tests, the modified tester can be used to measure indirectly the tensile and compressive strengths of the foam. As shown in Figure 2, a direct correlation was found between these quantities and the modified-durometer hardness for the PDL-4034 (or equivalent) foam.

This work was done by D. L. Hauser, D. F. Buras, and J. M. Corbin of Martin Marietta Corp. for **Marshall Space Flight Center**. *MFS-28147*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE

Medicine & Biology

1214 AST Enzymes Levels can be Checked with New Materials

1215 3-Amino-L-tyrosinc and Its Derivatives as Anti-inflammatory and Immuno-suppressive Compounds

1216 Research Shows That Transdermal (Skin) Patch May Be an Improved Method of Administering Hormones

1217 Prehensile Foot Restraint — Underwater or in space, this device would boost productivity.

Testing & Instrumentation

1218 Simple Breath Test Developed for Peptic Ulcer Patients

1219 Test and Evaluation Planning Guide for Aeromedical Equipment

NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

AST Enzymes Levels can be Checked with New Materials

A reference material (RM) aimed at improving the precision of tests for elevated levels of the enzyme aspartate aminotransferase (AST) is now available from NBS. Levels of the enzyme in blood are important because, if elevated, they can indicate a variety of clinical disorders. Among these are heart attacks, congestive heart failure, hepatitis and liver disease. The enzyme value found in the new RMs, while not certified, was derived from an interlaboratory study in which 10 analytical laboratories participated. The new material also was produced from human blood sources. (An NBS standard reference material currently for sale, Human Serum, contains a non-certified value for AST, but the enzyme in this case is from non-human sources.) Packaged in vials, the new reference material, Aspartate Aminotransferase (AST) (E.C.2.6.1.1.)Human Erythrocyte Source (RM 8430), is freeze-dried and intended for reconstitution with.2 milliliters of water. It contains 96.1 international enzyme units per liter, plus or minus 2.6 units.

For Additional Information:

It is available for $120 per set of three vials from the Office of Standard Reference Materials, B311 Chemistry Building, National Bureau of Standards, Gaithersburg, Md. 20899; (301) 975-6776.

Technology Assessment
Department of the Air Force

3-Amino-L-tyrosinc and Its Derivatives as Anti-inflammatory and Immunosuppressive Compounds

DESCRIPTION

Injection of the peroxidase inhibitor 3-amino-1.-tyrosine into animals suppresses the specific immune response necessary for rejection of transplanted tumor. 3-Amino-L-tyrosine and its derivatives inhibit, prevent, or reduce the cytotoxic effects of oxidants that form as a consequence of physical or chemical insult or inflammatory reactions.

STAGE OF DEVELOPMENT

The in vitro antioxidative and protective effects of 3-amino-L-tyrosine (3AT) have been reproduced in three separate laboratories. Specifically, 3AT has demonstrated radioprotective and thermoprotective properties at the cellular level, has inhibited oxidase and peroxidase cytotoxicity in vitro and in vivo, and has inhibited superoxide and peroxide production by macrophates in vitro. Currently, effects on prostaglandin, leukotriene, lymphokine, and monokinc production are being examined. In addition, 3 AT effects on lymphocyte effector cells (i.e., cytotoxic T cells) and its radioprotective properties are being explored.

APPLICATION

3-Amino-L-tyrosine and its derivatives may prove to be broad spectrum anti-inflammatories with applications as therapeutics in treatment of arthritis, scleroderma, systemic lupus, asthma and other respiratory diseases, endotoxemia, allergies, and cachexia. These compounds may also be useful in controlling rejection of transplanted tissues and organs.

PATENT STATUS

Two U.S. patents pending - AF Inv 14,155A: Method and Composition for Immunosuppression and AF Inv 17,468: Method of Prevention of Oxidative Injury.

PUBLICATIONS

1. Kiel, J.L., and Erwin, D.N. Physiologic Aging of Maturc Porcine Erythrocytes: Effects of Various Metabolites, Antimetabolites, and Physical Stressors. American Journal of Vetcrinary Research 47:2155-2160 (1986).

2. Lefkowitz, D.L., Lefkowitz, S.S., Wei, R.Q., and Everse J. Activation of Macrophages with Oxidative Enzymes in Methods in Enzymology 132:537-548 (1986).

FOR FURTHER INFORMATION CONTACT:

Johnathan L. Kiel, Maj, USAF, BSC USAF-SAM/RZP Brooks AFB, TX 78235-5301 AV 240-3583

or

Lt Marilyn Rucker USAFSAM-ORTA Brooks AFB, TX 78235-5301

NIH
Research & Technology

U.S. Department of Health and Human Services Public Health Service National Institutes of Health

Research Shows That Transdermal (Skin) Patch May Be an Improved Method of Administering Hormones

A study at the University of California at Los Angeles showed that estrogen (estradiol) given by skin patch did not carry the risks of estrogens taken in pill form (conjugated estrogens). Yet, the patch appeared to be as effective as pills in maintaining calcium balance. NIA-supported scientists Drs. John K. Lu and Howard L. Judd measured the blood levels of estrogen in 23 postmenopausal women who received supplemental estrogens either orally or by skin patches. They also studied the effects of the two methods of administration on several liver functions.

The new method of administering estrogen through a transdermal (or skin) patch uses a transparent adhesive patch which is attached to the abdomen. Low doses of estrogen are absorbed from the drug reservoir in the patch. Each patch is used for 3 days. Because release of estrogen from the skin patch more closely resembles the way estrogen is released naturally by the ovaries—entering the blood stream without going first to the liver—scientists believe it may be a safer way to administer estrogen to postmenopausal women. Both methods raised the level of estrogen in the blood to similar levels. However, oral administration had significant undesirable effects on several liver functions, while transdermal administration did not.

At the time of menopause a woman's body markedly decreases its production of estrogen. One result of this decrease is an accelerated loss of bone (osteoporosis), especially during the several years immediately after menopause. Pills containing synthetic estrogen sometimes are prescribed for postmenopausal women to prevent or slow down the development of osteoporosis, a disease resulting in weakened bones that are prone to fractures. Currently, estrogen therapy is considered one of the most effective methods for reducing bone loss.

Persons at highest risk of developing osteoporosis include white (Caucasian) women who have early or surgical menopause (before age 45). Other high-risk factors include extreme inactivity, use of corticosteroid medicines (prescribed to reduce inflammation, especially in patients with arthritis), and having a slight build. A chronically low intake of calcium in the diet, smoking cigarettes, and an excessive use of alcohol also can contribute to the development of osteoporosis. When estrogen replacement is used to prevent bone loss, it usually is started soon after menopause and continues for the following 5 to 10 years.

The standard method of administering estrogen—through pills taken by mouth—has a number of adverse side effects, including an increased risk of developing gallstones and hypertension, which are caused by the effects of estrogen on the liver. In addition, patients often do not receive the full benefit of estrogens administered orally, either because the liver breaks the hormones down and removes them from the blood before they are fully distributed to the site of the action, or because the hormones are digested before they can act.

Skin patch administration of estrogen has several unique features that make it attractive. It delivers estrogen at a constant rate, resulting in sustained estrogen levels in the blood and constant rates of excretion; this allows the physician to monitor the circulating levels and easily adjust dosage. Also, the patch can be applied and removed without difficulty, which encourages patient compliance.

Although further studies are needed to confirm the safety of estrogen administration through skin patches, as well as its effectiveness in retarding bone loss, this research points the way toward an improved and safer means of replacing estrogen and preventing osteoporosis.

For Additional Information:

To locate information or professional contacts on this effort, contact:

NIH News Branch,
Bldg. 31, Room 2B-10,
9000 Rockville Pike,
Rockville, MD 20892
(301) 496-2535

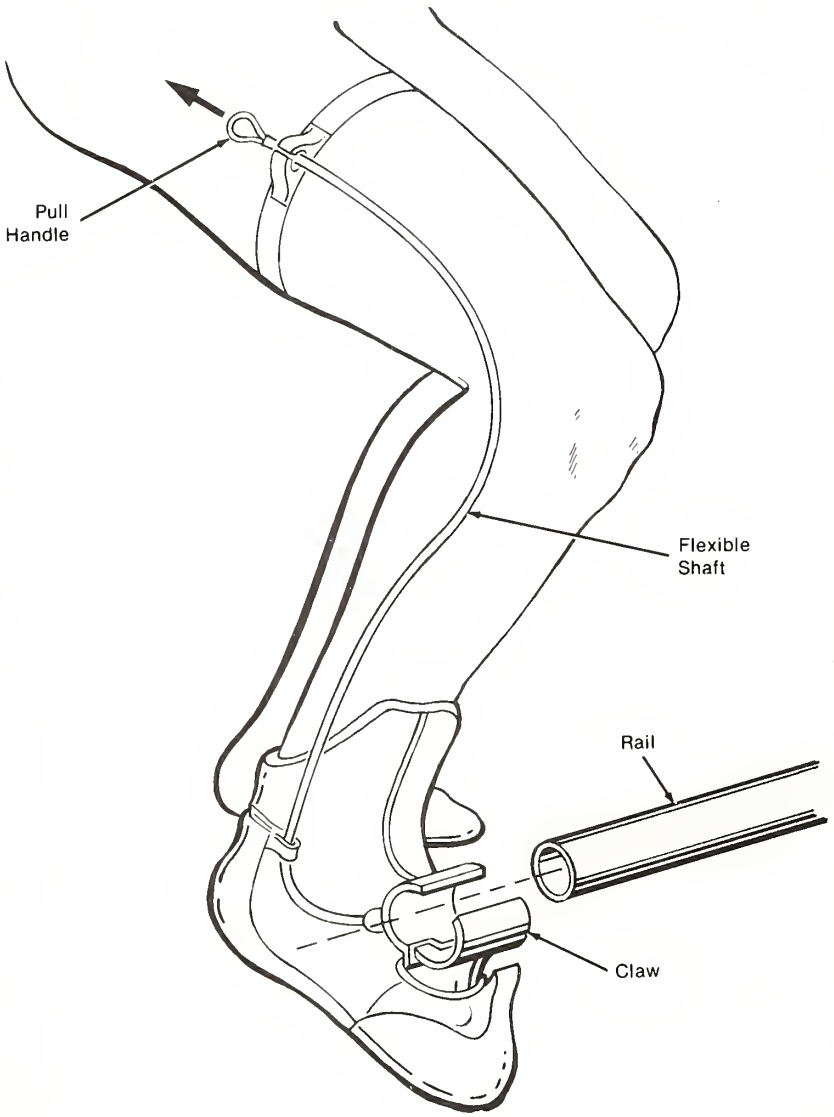
Refer to News & Features 7/87

NASA Tech Brief
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Prehensile Foot Restraint

Underwater or in space, this device would boost productivity.

A proposed prehensile foot restraint would enable such workers as astronauts and divers to maintain fixed positions in zero gravity or in buoyancy with minimal effort. With the foot restraint, a worker could devote attention more fully to the task at hand, with little concern about holding on to a supporting structure.



A **Claw Near the Toe of a Shoe** would grip a rail. The wearer would use the flexible shaft, first to lock the claw tightly on the bar; then, when the work is done, to open the claw.

The concept calls for a clawlike fixture on each of the worker's feet (see figure). The claw would grip a rail in the work area, fixing the worker's position without awkward belts or torso clamps.

Positioned on the top of the foot between the toes and arch, the claw would be easily seen by the wearer. To lock onto a rail, the wearer would bring the top of the foot under the rail. The act of bringing a claw in contact with the rail would activate a mechanism to close the claw loosely. Later, when the wearer is in the desired orientation and position on the rail, the wearer can activate a locking mechanism to make the claw grip the rail tightly. With both feet thus engaged, the wearer will be securely perched on the rail, much like a bird on a branch.

The locking mechanism would be operated through a flexible shaft extending from the claw along the leg to midthigh, where the shaft handle could be easily reached. The same shaft would be used to release the claw when the worker is ready to move. The shaft would not interfere with joint movement at the ankle, knee, or hip.

Two shafts — one on each leg — could be extended and joined on a girdle at the abdomen. The wearer could then lock or release both claws simultaneously with a single motion.

Two other methods of activating the locking/unlocking mechanism are also proposed. In a system based on over-center latching and releasing, the wearer could simply pull the shaft; the first pull would latch, and the second would unlatch. Alternatively, to lock the claw, the wearer could turn a spin-wheel- or water-faucet-type double-acting helix drive to pressurize a hydraulic gel in the shaft against a piston that is spring loaded in the "open" position. To unlock and open the claw, the wearer would turn the wheel to relieve the hydraulic pressure.

This work was done by Charles A. Willits of Rockwell International Corp. for **Johnson Space Center**. *No further documentation is available.* *MSC-21071*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE

United States Department of Agriculture

Research Technology
Agricultural Research Service

Simple Breath Test Developed for Peptic Ulcer Patients

A simple breath test can now replace the unpleasantness of swallowing a flexible tube to detect a bacterium suspected of playing a role in causing peptic ulcers. The patient first drinks a glass of water containing urea made with a harmless form of heavy carbon. If the alleged culprit, Campylobacter pylori, is in the stomach, it will quickly split the urea into ammonia and heavy carbon dioxide, which is exhaled in the breath.

Tried on 26 people, the breath test was as accurate in detecting the bacterium as a tissue biopsy taken through the tube. It should help scientists understand how ulcers form as well as design better 1 treatments. The research was supported 1 by the Veterans Administration, National Institutes of Health, the Agricultural (Research Service, and Baylor College of Medicine.

FOR FURTHER INFORMATION CONTACT:

Peter D. Klein
Children's Nutrition Research Center
at Baylor
Houston, TX
(713) 799-6000

Technology Assessment
Department of the Air Force

Test and Evaluation Planning Guide for Aeromedical Equipment

The planning guide for aeromedical equipment establishes uniform methods for test and evaluation of medical equipment to determine suitability for use in the military aeromedical evacuation environment. The test and evaluation methods contained in the guide are not considered to be all inclusive, nor applicable to all equipment items requiring evaluation. Therefore, specific performance standards for individual items of equipment must be outlined in the particular equipment test protocol.

The planning guide addresses both evaluation and test methods. Evaluation methods include: general characteristics, physical characteristics, and human factors. Test methodology incorporates: environmental assessments (i.e. altitude, decompression, high and low temperature, and humidity), physical characteristics (vibration), electrical characteristics (electromagnetic characteristics, leakage current, ground resistance, and insulation), and inflight feasibility.

This document should be used as an informative guide _ providing generic approaches for aeromedical equipment evaluations. Each item of equipment will require a specific test protocol to be established based upon its individual characteristics, use, and anticipated operating environments.

Applications: Test and evaluation of medical equipment for aeromedical evacuation use.

ADDITIONAL INFORMATION:

Aeromedical Evacuation Group, USAFSAM/VNC
Brooks AFB, TX 78235-5301; 512-536-2937

Additional Reference: USAFSAM-TR-86-10, *Status Report on Medical Materiel Items Tested and Evaluated for Use in the USAF Aeromedical Evacuation System.*

Natural Resources Technology & Engineering

1220 CLICOM—A Microcomputer Database Management System for Routinely Collected Data

1221 Better Face Ventilation for Mines With Large Entries

1222 Geodetic Glossary Available

NOAA Technology Brief

National Oceanic and Atmospheric Administration

National Environmental Satellite, Data, and Information Service
National Climatic Data Center

CLICOM — A Microcomputer Database Management System for Routinely Collected Data

A World Meteorological Organization (WMO) project, CLICOM was developed at NOAA's National Climatic Data Center (NCDC) in Asheville, N.C., to provide developing countries with a uniform microcomputer based system for storing, retrieving, analyzing, and verifying weather data. The primary goal of CLICOM is to rescue valuable and irreplaceable climatic data that in many countries are stored on deteriorating paper records. But the system can also be useful to consulting meteorologists, farmers, state climatologists, construction planners, and others.

The system provides capabilities to control all aspects of data management. In addition, it manages detailed historical information on the locations and observing practices of stations, data dictionary information, and data inventories. It will work with any data taken on a regular monthly, daily, or hourly schedule. The current system supports over 150 standard climatological parameters and allows users to add more than 800.

To simplify use by personnel with little technical training, CLICOM is menu driven. The menu guides users to the task of interest, where they can then provide specific information by filling in standard forms. This approach provides novice users with all of the information required to perform most tasks. To help novice users familiarize themselves with the system, extensive on-line help is available.

Statistical and graphical products that can be computed include: monthly data from daily; monthly means and extremes; daily means and extremes; bivariant frequency distribution for any parameter; monthly graphs of daily data; annual graphs of monthly data; as well as monthly data tabulations including means, extremes, and daily values.

The minimum acceptable configuration is given below. Cost is about $12,000 for both the hardware and software.

IBM PC/AT - compatible microcomputer with:

- 1 megabyte (MB) memory
- 1.2 megabyte (MB) diskette drive
- 40 megabyte (MB) hard disk
- Enhanced graphics adaptor
- 1 serial, 1 parallel port
- 80287 math coprocessor
- Enhanced color monitor

Backup device (e.g., 60 MB cartridge tape or ISI optical disk drive 120/240 MB)

IBM graphics-compatible printer.

Required commercial software: PC/MS DOS 3.1, DataEase 2.5, COSORT, FORTRAN 3.31, GRAFMATIC, and FORLIB PLUS. CLICOM software modules developed at NCDC are integrated with the commercial software package.

Intensive one-week CLICOM training sessions will be held at NCDC in Asheville, N.C. These sessions cover a variety of topics related to the use of the CLICOM system. The sessions will be held whenever 10 or more users have requested training. Cost is $300 per person.

Additional information on the CLICOM System is available from the NOAA ORTA, Suitland Professional Center (SPC), Room 307, Washington, D.C. 20233. Telephone (301) 763-4240.

Technology News

From the Bureau of Mines, United States Department of the Interior

No. 279

Better Face Ventilation for Mines With Large Entries

Objective

Improve face ventilation in mines with large cross-sectional entries.

Approach

Oil shale, salt, and limestone mines typically have large entries. Providing adequate airflow to the working faces of such mines for worker comfort, health, and safety is a substantial ventilation problem. If diesel equipment is used at the face or if a methane hazard exists in the mine, the problem becomes even more complex. To address this problem, a study was conducted under a joint contract between the Oil Shale Committee of the Colorado Mining Association and the Bureau of Mines. The study evaluated two face-ventilation concepts for large-entry mines.

Improving Ventilation

Two face-ventilation systems were selected for testing of an oil-shale mine, based on results of a cost/benefit analysis. The systems were a free-standing jet fan and a ducted fan operating in the blowing mode. The jet fan was spotted on the intake side in the mouth of the entry being advanced with final positioning, in or out, determined by minimum recirculation. The ducted fan was also positioned in the mouth of the entry being advanced, with its tubing terminating 75 feet from the working face. The mine face entry was a dead heading 55 feet wide, 30 feet high, and 320 feet long. Sulfur hexafluoride (SF_6) tracer gas was used to measure the performance of the two systems in diluting mine face pollutants including after-gases from blasting, hot diesel emissions, methane roof layers, and methane emitted from muckpiles.

Jet fan at the mouth of a dead-ended large mine entry.

Test Results

The performance of the two fan systems was evaluated in terms of their dilution efficiencies as measured with the tracer gas. The dilution efficiency is the ratio of the quantity of air actually ventilating the face area to the quantity of air being supplied by the fan. For a perfect ventilation system, all of the air supplied by the fan would be uniformly mixed with all of the pollutants in the face area, and the dilution efficiency would be 1. A comparison of the two systems in

Comparison of Fan System Dilution Efficiencies

Simulated pollutant	Jet fan (88,400 ft³/min)	Ducted fan (blowing) (90,700 ft³/min)
Blasting pollutants	0.75	0.98
Diesel exhaust	0.78	0.74
Methane layering	0.59	0.83
Methane from muckpiles	0.79	0.60

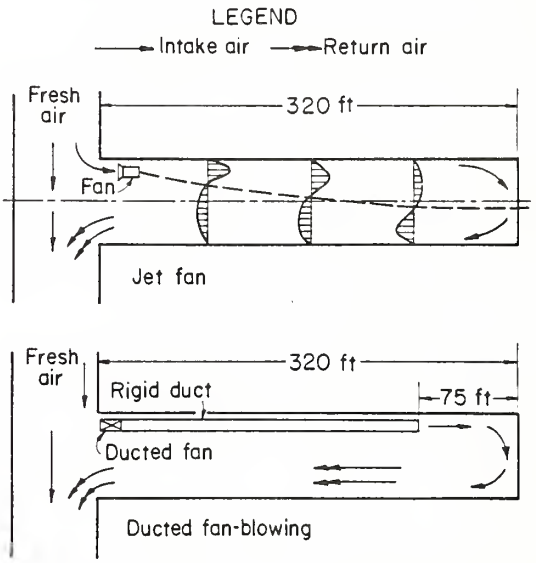
terms of their respective dilution efficiencies is presented in the table.

The jet fan was more effective at removing diesel exhaust and methane from muckpiles; the ducted fan was more effective at removing pollutants from blasting and at breaking up methane layers. However, based upon face pollutant levels measured in mines with large entries, the dilution efficiencies determined from the tests show that for ordinary mining operations both ventilation systems would provide enough ventilation to maintain pollutants at levels below their Threshold Limit Value's (TLV's). While comparable strictly from a ventilation viewpoint, the jet fan system offers some advantages over the ducted fan system. It is much easier and faster to install than the ducted fan system, and the jet fan can be easily moved from one entry to another making it more likely to be used on a regular basis. The tubing with the ducted fan system requires much more time to install and could be subjected to blasting damages, whereas the jet fan is far enough from the face that blast damage is unlikely. However, if blast damage to the jet fan is a possibility, the jet fan can be easily moved to a safer location. Also, based on power consumption per effective cubic foot of air flow, the jet fan delivered similar performance at about 30 percent less power consumption than the ducted fan. For both systems, dilution efficiencies could be significantly improved, possibly by as much as 20 percent, if care is taken to minimize fan inlet recirculation. This can be done by running a short section of tubing from the fan inlet upstream beyond the intersection.

For More Information

A Bureau of Mines Information Circular (IC 9118), titled "Face Ventilation for Oil Shale Mining contains additional details about the results of this research: For a free single copy of this report, please write to the Bureau's Publication Distribution Section, PO Box 18070, Pittsburgh, PA 15236.

Questions about this research maybe directed to Edward D. Thimons, the technical project officer for this work, at the Bureau of Mines Pittsburgh Research Center at the aforementioned address, or telephone him at (412) 675-6683.



Schematic of the jet fan and ducted fan ventilation systems in a mine.

Laboratory Technology

Fish & Wildlife Service
U.S. Department of the Interior

Geodetic Glossary Available

This glossary is a revision of "Definitions of Terms Used in Geodetic and Other Surveys" (U.S. Coast and Geodetic Survey Special Publication 242) by Hugh C. Mitchell, published in 1948. Since Mitchell's book appeared, the standards, instruments, theory, and procedures of that time have been markedly changed, complemented, reduced in importance, or completely replaced by new ones. In addition, the interaction of geodesy with other disciplines has greatly increased, which demands that these relationships be covered also.

Examples of the considerable changes since 1948 can be found in almost every single page of this glossary. Invar tapes have been mostly replaced by electronic devices which employ light, infrared, or radio waves. Photogrammetry has become an important method of acquiring geodetic information. Observations on artificial satellites have become an important method of acquiring geodetic information. Observations on artificial satellites have become a dominant source for information on both geometric positioning and the determination of the gravity field. The computational aspects of geodesy have been just as heavily affected. Adjustment by solving for angles and distances has been superseded by solving for coordinates. Forms that depended on tables or mechanical calculators have disappeared in this age of electronic computers. The geodetic datums of 40 years ago are of interest today mainly to historians.

Such a variety of changes and additions has swelled the number of definitions from 800 to almost 5,000. Even this sixfold increase will omit many terms which should be rightly included, but are missing because it was well-nigh impossible to keep up with the rapid innovation in geodetic theory and practice. For example, the revolution in geodetic positioning due to the implementation of the Global Positioning System (GPS) is barely touched on here; the enrichment to the geodetic vocabulary entailed by GPS will have to be documented in a future edition. The expansion in size of this glossary covers only a small part of the material available and considered. Selections had to be made, and the judgments reflect the inevitable biases of the compilers. In addition, users are bound to discover terms which are inexplicable missing. The reason for this is simple: human imperfection. Correspondence noting errors, omissions, or containing suggestions are welcomed in anticipation of a future set of addenda and corrigenda.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.

NTIS order number: PB87-181210/NAC

Price code: A13

Physical Sciences

1223 Material Structure in Viscoplasticity — An extension of Bodner's Theory

1224 Thermodynamic Data for Biomass Conversion and Waste Incineration — Compiles data for more than 700 materials

1225 High Temperature Superconducting Device Operates at 81K

1226 Superconductors: Initial Study of Electronic Structure in Y-Ba-Cu-O

1227 Catalytic Oxidation of CO for Closed-Cycle CO2 Lasers — Stoichiometric mixtures are converted completely.

1228 Isotope Exchange in Oxide Catalyst — A replacement technique maintains the level of CO2(18) in closed-cycle CO2 lasers. (Licensing Opportunity)

1229 Pretreatment of Platinum/Tin-Oxide Catalyst — The addition of CO to a He pretreatment doubles the catalytic activity. (Licensing Opportunity)

1230 Algorithm for Fluid Networks — Flow systems can be simulated to almost any degree of detail.

1231 Cryogenic Shutter — A simple design includes no bearings or other rubbing components. (Licensing Opportunity)

1232 Optical Emission End-Of-Process Detection for Plasma Cleaning (Licensing Opportunity)

Other items of Interest

1281 Device Measures Alcohol Level in Peanuts

U.S. Army Research

Material Structure in Viscoplasticity

An extension of Bodner's Theory

Bodner's constitutive equation is used to model viscoplastic deformation. This particular equation is useful because of its relative mathematical simplicity, partly due to the elimination of the need for a yield surface. However, Bodner's formulation is not without problems, such as difficulties in fitting the material constants of the equation to data, and a general deficiency of the model to properly account for hardening phenomena. Deficiencies in the hardening behavior of Bodner's equation likewise imply that similar deficiencies probably exist for the softening behavior caused by the accumulation of material damage in the form of voids or microcracks. These deficiencies led to the definition of the present work, the objectives of which were:

(1) to improve the capabilities of Bodner's viscoplastic constitutive equation for modeling deformation-induced hardening phenomena by incorporating microstructural models into the equation, and

(2) to develop a continuum formulation that simultaneously represents the mechanics of both hardening and damage behavior, with the ultimate aim of developing a new material state tensor.

Although Bodner's viscoplastic constitutive equation is useful because it does not require a yield criterion, it also exhibits deficiencies related to hardening behavior. Two new constitutive forms were developed from Bodner's equation to address this problem. The general approach employed scaling relations to define macrostructural response in terms of microstructural evolution. The first new equation expresses strain rate as a function of scaled microstructural models available from the metallurgical literature, and is useful for structural analyses. The second new equation represents a nonlocal model for viscoplasticity. It describes the evolution of internal stress field fluctuations in terms of scaled hardening and damage state variables, and contains the basis for a new material state tensor. The two new equations were verified by comparison to creep data for a steel alloy and aluminum, respectively.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.

NTIS order number: AD-A174990 /2/NAC

Price code: A04

Thermodynamic Data for Biomass Conversion and Waste Incineration

Compiles data for more than 700 materials

The general purpose of this collection of thermodynamic data of selected materials is to make property information available to the engineering community on chemical mixtures, polymers, composite materials, solid wastes, biomass, and materials not easily identifiable by a single stoichiometric formula. Workers in many sectors need this type of information: construction engineers who require thermodynamic information on materials, safety engineers assessing the hazard potential of chemicals, chemical engineers concerned with industrial unit processes, and scientists who want thermodynamic data for specific research projects.

The specific purpose of this publication is to provide engineers involved in combustion and thermochemical conversion with appropriate thermodynamic data so that they can dispose of waste materials and utilize biomass for energy in a more effective and environmentally acceptable manner. The effective disposal of waste materials is an important part of the maintenance of a high-quality environment, and combustion/thermochemical conversion offers the most significant means of volume reduction for waste materials when compared to other methods of disposal. In addition, the potential of biomass for energy is being increasingly recognized and realized.

This compilation of thermodynamic data was prepared for the Solar Energy Research Institute (SERI) by the Chemical Thermodynamics Data Center of the National Bureau of Standards. More than 700 materials have been compiled covering properties such as specific heat, gross heat of combustion, heat of fusion, heat of vaporization, and vapor pressure. The information was obtained from the master files of the NBS Chemical Thermodynamics Data Center, the annual issues of the *Bulletin of Chemical Thermodynamics*, intermittent examinations of the *Chemical Abstracts* subject indexes, individual articles by various authors, and other general reference sources.

The compilation is organized into several broad categories; materials are listed alphabetically within each category. For each material the following are given: (1) the physical state, (2) information as to the composition or character of the material, (3) the kind of thermodynamic property reported, (4) the specific property values for the material, and (5) citations to the reference list. A name index is provided to assist a user in finding a specific material.

Several appendices are also included. Appendix A gives an empirical formula that allows heats of combustion of carbonaceous materials to be predicted with surprising accuracy when the elemental composition is known. A spread sheet illustrates this predictability with examples from this report and elsewhere. Appendix B lists some reports containing heats of combustion not included in this publication. Appendix C contains symbols, units, conversion factors, and atomic weights used in evaluating and compiling the thermodynamic data.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.

NTIS order number: DE86-014515/NAC

Price code: A15

NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

High Temperature Superconducting Device Operates at 81K

Scientists at the NBS Boulder Laboratories have demonstrated what may be the first superconducting electronic device to operate at 81 kelvin--above the liquid nitrogen temperature of 77 K. The superconducting quantum interference device, or SQUID, is a high-temperature version of the most sensitive existing device for measuring magnetic fields. In the future these high-temperature devices may replace important elements of the common electrocardiogram, and be used for prospecting and in computers. Dr. James E. Zimmerman, a recently retired NBS physicist now working in the bureau's Boulder laboratories as a guest researcher' designed and constructed the SQUID. The yttrium-barium-copper oxide material' which permitted the device to operate up to 8I K. was made at NBS by Dr. Ronald Ono and Mr. James Beall of the bureau's Center for Electronics and Electrical Engineering. In another development at NBS, Drs. John Moreland and Alan Clark observed the ac Josephson effect above 77 K. confirming that electrons in these new materials are paired as they are in conventional superconductors. Devices based on this effect may become future microwave detectors and sources and voltage standards.

For Additional Information:

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NBS technology update

National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Superconductors: Initial Study of Electronic Structure in Y-Ba-Cu-O

Researchers in the NBS Surface Science Division have published one of the first papers on the electronic structure of the high-temperature superconducting ceramic

Electronic structure' which describes the energy levels of electrons in the material' is a critical piece of information for understanding the still-mysterious mechanism of high-temperature superconductivity. In experiments run in collaboration with colleagues from the Naval Research Laboratory, physicists Richard Kurtz and Roger Stockbauer used the NBS synchrotron light source and resonant photoemission to map the electronic structure above and below the transition temperature for superconductivity, and to identify the atoms which contribute to the important valence bands of the structure. The data show no major changes in electronic structure with the transition to superconductor- that the predominant copper valence state comes from Cu^{2+} atoms. Both results should significantly affect current efforts to develop a theory of high-temperature superconductivity.

For Additional Information:

Resonant Photoemission Study of Superconducting Y-Ba-Cu-O appears in the Rapid Communications section of the June 1 issue of Physical Review B.

NASA Tech Brief
National Aeronautics and Space Administration
Langley Research Center, Hampton, Virginia

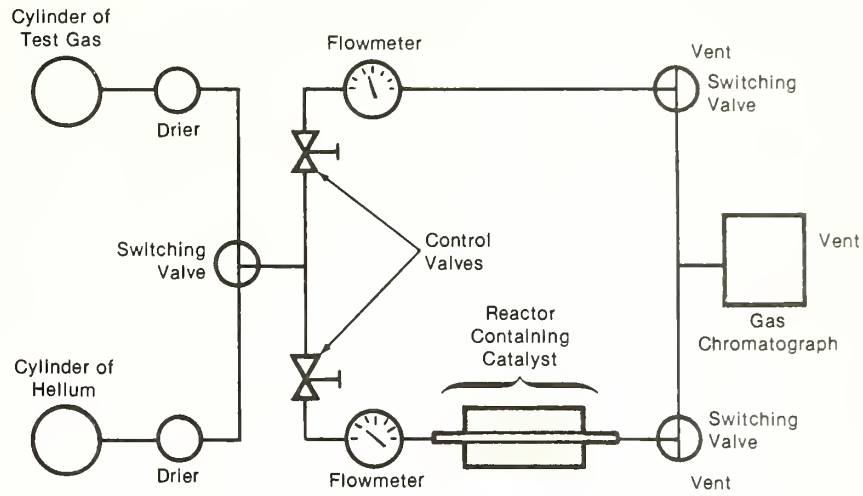
Catalytic Oxidation of CO for Closed-Cycle CO_2 Lasers

Stoichiometric mixtures are converted completely.

High-energy pulsed CO_2 lasers have a potential for measuring many different features of the atmosphere of the Earth and are particularly useful on airborne or space platforms. For this type of application, the laser must be operated in a closed cycle to conserve gas, especially if rare nonradioactive isotopes of carbon and oxygen are used. However, the laser discharge decomposes a fraction of the CO_2 to CO and O_2, causing a rapid loss in power and leading to erratic behavior. To maintain operation, the CO and O_2 must be recombined to form CO_2.

Recombination can be caused by passing the gas mixture over a heated, solid catalyst. Although many catalysts can oxidize CO to CO_2, some are unsuitable for laser operation because they need an oxidizing atmosphere of about 20 percent O_2. However, in the CO_2 laser, the O_2 concentration must be kept below a few tenths of a percent to maintain laser power. Previous work has shown that a 1-percent Pt/SnO_2 catalyst tested with a gas mixture of 1 percent CO and 0.5 percent O_2 showed considerable removal of CO and O_2. Therefore, an effort was undertaken to develop a basis for the design of a 1-percent Pt/SnO_2 catalyst bed for a closed-cycle CO_2 laser and to determine the reaction mechanism of CO and O_2 on the Pt/SnO_2 catalyst surface.

The figure shows one of the experimental systems used to obtain kinetic data on the reaction of a stoichiometric mixture of CO and O_2 on a 1-percent Pt/SnO_2 catalyst. The gas mixture, or test gas, was sampled at either the test-gas cylinder (reactor bypass) or the reactor outlet and analyzed by a gas chromatograph. The test gas was a mixture of 1 percent CO and 0.5 percent O_2 in ultrapure (99.999 percent before mixing) helium. About 0.2 percent neon was added to this mixture as an internal calibration standard.



The **Test Gas**, consisting of CO and O_2 in He, is used to simulate the production of CO and O_2 from CO_2 in a laser. Thus, the apparatus serves as a surrogate laser system to obtain kinetic data for the reaction on the catalyst.

In the surrogate laser system using 0.925 g of the 1-percent Pt/SnO_2 catalyst (BET* surface area per unit mass of 6.7 m^2/g), complete conversion of the stoichiometric gas mixture occurred at 100 °C and a flow rate of 10 standard cubic centimeters per minute. From these data, it was determined that a reactor in a closed-cycle CO_2-laser system using 925 g of catalyst at 100 °C should operate indefinitely with a circulating gas flow of 10,000 standard cubic centimeters per minute. An analysis of the kinetic data suggested a rate law for the reaction that is overall first order. However, further experiments with nonstoichiometric gas mixtures of CO and O_2 are planned to determine the order of the reaction with respect to the CO concentration and the order of the reaction with respect to the O_2 concentration in the rate law.

*BET refers to the Brunauer, Emmett, and Teller method of measuring the real surface area of a solid by nitrogen adsorption.

This work was done by I. M. Miller, D. R. Schryer, R. V. Hess, B. D. Sidney, G. M. Wood, Jr., and P. A. Paulin of **Langley Research Center** *and B. T. Upchurch and K. G. Brown, of Old Dominion University.*
Further information may be found in NASA TM-86421/NSP [N85-25445], "Optimization of the Catalytic Oxidation of CO for Closed-Cycle CO_2 Laser Applications."

Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161, [A02]
LAR-13505/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD. 21240; (301) 621-0100 Ext. 241*
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NASA Tech Brief
National Aeronautics and Space Administration
Langley Research Center, Hampton, Virginia

Licensing Opportunity

Isotope Exchange in Oxide Catalyst

A replacement technique maintains the level of CO_2^{18} in closed-cycle CO_2 lasers.

High-energy, pulsed CO_2 lasers using rare chemical isotopes must be operated in closed cycles to conserve gas. Such rare isotopes as CO_2^{18} are used for improved transmission of the laser beam in the atmosphere. However, closed-cycle operation results in a rapid power loss caused by the disassociation of CO_2 into CO and O_2 in the electrical discharge of a laser. To maintain laser power, the CO_2 must be regenerated, and the O_2 concentration must be kept below a few tenths of a percent. These conditions can be achieved by recombining the CO and O_2.

One method for recombining CO and O_2 is to use a solid catalyst. To conserve energy, the catalyst must be active at or below 100 °C, the temperature inside the laser envelope. Platinum on tin oxide (Pt/SnO_2) meets this requirement. However, reactions of CO_2^{18} and O_2^{18} with Pt/SnO_2^{16} result in the formation of some $CO^{16}O^{18}$ at temperatures from 25 to 100 °C. To maintain isotopic integrity of the CO_2^{18} in the laser gas mixture, the catalyst must also contain only O^{18} atoms at reactive oxide sites. Instead of using a very expensive procedure like preparing the catalyst with reagents containing only O^{18} atoms, a less costly technique involves removing all active O^{16} atoms at or near catalyst surface and replacing them with O^{18} atoms.

A sample of 1 percent Pt/SnO_2 was heated to 300 °C in flowing Ne and then chemically reduced in flowing H_2 for 5 minutes. Removal of O^{16} (as H_2O^{16}) was monitored with a mass spectrometer. The sample was then reoxidized with 3 percent O_2^{18} in Ne for 50 minutes, cooled in flowing Ne to 100 °C, and then exposed to a stoichiometric mixture of 2 percent CO^{18} plus 1 percent O_2^{18} in Ne for 15 minutes. The product CO_2 was monitored with a mass spectrometer. The observed isotopic purity (CO_2^{18}/total CO_2) of the product CO_2 equaled the isotopic purity of the CO^{18} in the reactant gas mixture.

This work was done by Robert V. Hess, Irvin M. Miller, David R. Schryer, Barry D. Sidney, and George M. Wood, Jr., and Ronald F. Hoyt of **Langley Research Center**, *Billy T. Upchurch of Chemicon, and Kenneth G. Brown of Old Dominion University.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center Refer to LAR-13542/TN

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NASA Tech Brief
National Aeronautics and Space Administration
Langley Research Center, Hampton, Virginia

Licensing Opportunity

Pretreatment of Platinum/Tin-Oxide Catalyst

The addition of CO to a He pretreatment doubles the catalytic activity.

In a sealed, high-energy, pulsed CO_2 laser, CO and O_2 form as the decomposition products of CO_2 in the laser discharge zone. These products must be recombined, because an oxygen concentration of more than a few tenths of a percent causes a rapid deterioration of power, ending in unstable operation. A promising low-temperature catalyst for combining CO and O_2 is platinum on tin oxide (Pt/SnO_2). A new development increases the activity of the catalyst so that less is needed for the recombination process.

A catalyst pretreatment adopted at Langley Research Center was to expose a 120-mg sample of 1 percent platinum on tin oxide (1 percent Pt/SnO_2) to high-purity flowing helium for 1 hour at 225 °C. Then the sample was exposed to a gas mixture of 1 percent CO and 0.5 percent O_2 in He, flowing at 5 standard cubic centimeters per minute and 100 °C. The steady-state activity, measured in terms of the percent conversion of CO and O_2 to CO_2, occurred after 900 minutes at a level of 38 percent.

The new development is to replace the He used in the pretreatment with a mixture of 1 percent CO in He. With this new pretreatment, the steady-state activity after 500 to 900 minutes is between 74 and 78 percent or about twice the value obtained for the pretreatment with He alone.

In addition to the above development, a simple process to reactivate the catalyst for long-term use was devised. After about 50 hours, a small decrease in activity was noted. To counteract this decay, the temperature of the catalyst bed was raised to 225 °C while the reactant gas was flowing, held for 1 hour, then lowered to 100 °C. This procedure restored the activity of the catalyst to a level above its initial steady-state value.

This work was done by Robert V. Hess, Patricia A. Paulin, Irvin M. Miller, David R. Schryer, Barry D. Sidney, and George M. Wood of **Langley Research Center**, *Billy T. Upchurch of Chemicon, and Kenneth G. Brown of Old Dominion University.*

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NASA Tech Brief
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Algorithm for Fluid Networks

Flow systems can be simulated to almost any degree of detail.

An algorithm performs either a transient integration or a steady-state relaxation of a network that represents an internal fluid system. The algorithm is valid for both single and two-phase flow of any fluid and includes both heat-transfer and work (volume-change) terms. The algorithm is general enough to simulate almost any flow system to almost any degree of detail desired. The algorithm has been encoded into the computer program FLUINT, which will work in conjunction with the SINDA-85 program to enable the analysis of pipelines; heating, ventilating, and cooling systems; and almost any other system that involves both fluid flow and heat transfer.

The algorithm treats a fluid network as a collection of lumps and connectors. Lumps are tanks, junctions, and plena where mass and energy are conserved. Tanks are control volumes that can exchange energy with the environment and can grow or shrink. They are governed by differential equations for mass and energy. Junctions are zero-volume tanks that can be used to model tees, small tanks, or measuring points. Plena are tanks with infinite volume that represent boundary conditions for open systems and do not appear directly in the equations.

Connectors include tubes and paths. Tubes have significant line inertia and are governed by a differential equation for momentum. Paths have insignificant inertia and are represented by an algebraic relationship between the flow rate and the pressure differential. Paths can be used to simulate pumps, valves, loss factors, capillary passages, leaks, and small lines.

The system of differential equations that describes a network is built by the algorithm and then solved. Each differential equation that goes into the final formulation is written in such a general form that a choice among Eulerian (first-order explicit), first-order fully implicit, and trapezoidal (second-order fully implicit) solution methods is made simply by the selection of a constant. Eulerian methods are not suitable unless extremely small transient time steps or many small steady-state relaxations are taken. The algorithm automatically uses the trapezoidal method, which is unconditionally stable and accurate to second order, unless network conditions require that the first-order implicit method be used. One such condition is that which can give rise to water-hammer events; namely, the presence of nonexpandable tanks filled with incompressible fluid.

One consequence of the assumption of incompressible tanks is that the pressure is no longer governed by a differential equation and hence can change discontinuously. The algorithm may therefore perform a pressure-propagation solution. This is required only occasionally to maintain the desired accuracy during sudden events, but it has proved to be a major contributor to the ruggedness of the algorithm.

The algorithm would easily accommodate a compressible-liquid formulation for the resolution of water-hammer events. Other possible extensions of the algorithm include the effects of the flexibilities of containers, high-velocity flow, gravitation, acceleration, and the opening and closing of valves.

This work was done by Brent A. Cullimore of Martin Marietta Aerospace for **Johnson Space Center**. *MSC-21250 /TN*

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NASA Tech Brief
National Aeronautics and Space Administration
Goddard Space Flight Center, Greenbelt, Maryland

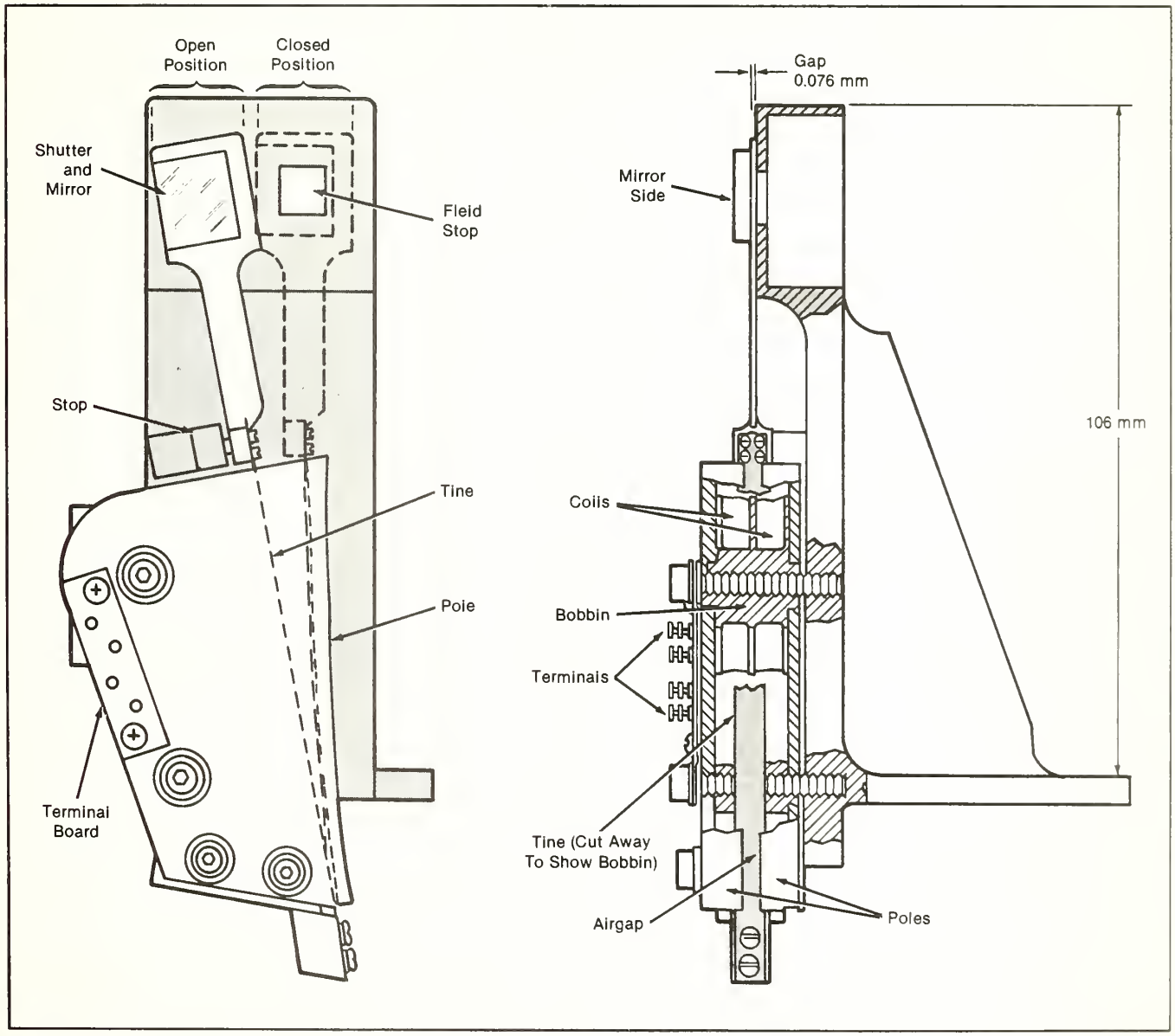
Licensing Opportunity

Cryogenic Shutter

A simple design includes no bearings or other rubbing components.

An electrically actuated shutter is designed to operate many thousands of times at cryogenic temperatures. When open, the shutter allows light at wavelengths between 1 and 300 μm to enter an instrument that measures background cosmic radiation. When closed, the shutter blocks outside radiation from the instrument and positions a mirror to reflect light from an internal source to the instrument so that it can be calibrated.

The shutter is designed to operate at least 50,000 times at 2 K, the operating temperature of the instrument. It draws less than 1 mW from the power supply. It is designed so that, if a power failure should occur, the shutter will remain in or assume the open position so that measurements



The **Shutter on the Moving End of the Tine** swings to cover the field stop when actuated by superconducting coils on the bobbin of an electromagnet. It comes to rest against a pole piece and assumes the cantilevered-beam contour of the piece. When the coils are de-energized, the tine returns to its relaxed, open position.

can continue, albeit without calibration.

Ordinary motors or solenoids could not be used in the actuating mechanism because of the low-power, low-temperature constraints. A further constraint was that the mechanism had to fit within a small predetermined volume.

The mechanism is magnetically operated. The magnet core consists of two curved pole pieces and a metal bobbin made from highly purified iron with low hysteresis and high saturation flux density. An aluminum flat mirror is attached to a flexible tine made of high-strength tool steel.

The bobbin is wound with two coils of superconducting niobium/titanium wire and vacuum-impregnated with Formvar (or equivalent) polyvinyl formal so that the windings are supported. Either of the two coils can actuate the shutter if the other fails.

The bobbin is sandwiched between the two pole pieces, each of which has the shape of a cantilevered beam uniformly loaded in bending. When the bobbin winding is energized, the tine takes the shape of the pole pieces, closing the shutter. The initial energizing current is 45 to 50 mA and lasts for 200 ms. It then drops to 12 mA to hold the tine and shutter in place. To prevent magnetic sticking, a 80-μm-thick nonmagnetic plating of copper and gold on the pole pieces maintains a small gap between the actuated tine and the pole pieces. When current is removed from the windings, the spring action of the tine returns the shutter to the open position.

The clearance between the instrument field stop and the closed shutter is 76 μm — close enough to block almost all of the incoming radiation. For futher blockage, a shutter retainer on three sides of the field stop provides a noncontacting labyrinth seal.

This work was done by Allen Tyler and Casey de Kramer of **Goddard Space Flight Center**.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Goddard Space Flight Center Refer to GSC-13068./TN

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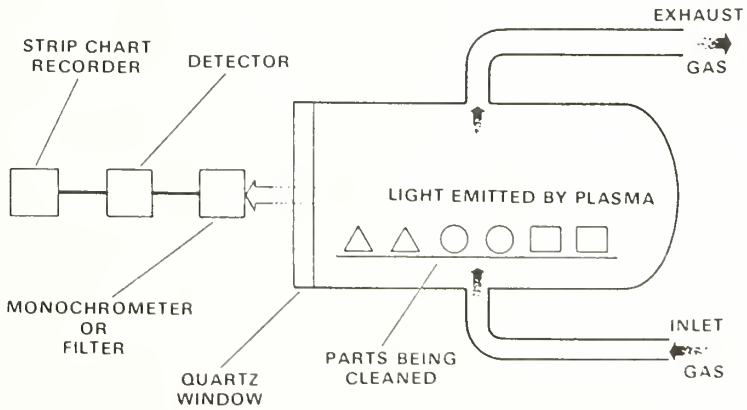
Optical Emission End-Of-Process Detection for Plasma Cleaning

An end-of-process detector was tested for plasma cleaning operations where organic contamination is removed. The detector uses optical emission spectroscopy to determine the concentration of certain reaction products remaining in the plasma chamber during processing. The output, in strip-chart form, is used to indicate the point at which no further cleaning is being accomplished and thus no further plasma processing is necessary.

The oxygen plasma removal of several different organic materials was monitored. Contaminants (paraffin wax and lubricating oil) and polymers (polymonochloroparaxylylene and Kapton polyimide) demonstrated completely different removal rates, with each having its own characteristic output curve.

Different filters on the detector allowed the monitoring of different wavelengths of light emitting from the plasma. Filters allowing the transmission of light in the wavelengths of 480, 560, and 656 nanometers were tested. These filters correspond to light emitted by activated species of carbon monoxide (480 nm and 560 nm) and hydrogen (656 nm). The hydrogen (656 nm) filter proved to be most sensitive to the removal of the materials being tested.



Schematic of Optical Emission Detector System

The study demonstrated the usefulness of the detector; however, it does have a major limitation in that it is only effective in monitoring plasma cleaning processes using pure oxygen as the plasma gases. A much more advanced spectrometer being tested in the cleaning of hybrid microcircuits is able to detect, in a similar yet more sophisticated manner, the end-points of plasma processes using gases other than pure oxygen.

FOR ADDITIONAL INFORMATION: A copy of the report is available from NTIS, Springfield, VA 22161; (703) 487-4600.

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Transportation

1233 Lightweight Monorail Transport System — Tubular rails have a high strength-to-weight ration.

NASA Tech Brief
National Aeronautics and Space Administration

Lightweight Monorail Transport System

Tubular rails have a high strength-to-weight ratio.

A report proposes a monorail transportation system for a zero-gravity environment. The system would carry materials and parts between locations on a space station.

The system would include tubular rails instead of the open channels usually found in overhead conveyor systems. Since the resistance to torque of a closed tube is greater than that of an open channel for the same amount of material, the tubular monorail can be designed for higher loads or for greater spacing between support points.

A vehicle on one fixed and one swivel truck would ride the monorail. The rails would incorporate supports and switch mechanisms within a 90° quadrant, allowing three-fourths of the rail surface to be used by the truck drive mechanism. The truck drive wheels would be powered by a gearmotor through a drivebelt. Rollers on opposite sides of the truck would ride in grooves on the sides of the monorail; they would hold the truck on the rail and minimize sidesway.

The torque loads induced by the truck motion would be transmitted by a pin at one end of a rail segment and by a sliding tongue within a fixed groove at the other end of the rail segment. Where a rail connects to the space-station structure, the torque loads would be transmitted by pin connections. Each rail segment would be longitudinally independent of the space-station structure so that thermal expansion and contraction stresses would not be transmitted.

This work was done by Harold F. Weir, Kenneth E. Wood, and Myron T. Strecker of Rockwell International Corp. for **Johnson Space Center**. *To obtain a copy of the report, "Monorail Transport for Zero-G Environment," MSC-21119 /TN*

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